SCIENTIFIC AGRICULTURE

Vol. X. JANUARY, 1930 No. 5

INHERITANCE OF PLUMAGE AND SKIN COLOR IN THE ANCONA

V. S. Asmundson and Helen I. Milne
University of British Columbia, Vancouver, B.C.

[Received for publication August 19, 1929]

Considerable information dealing with the genetic composition of various breeds of poultry has been published in the last few years. Our knowledge is, however, still incomplete and fragmentary, so that much remains to be done. This applies even to the inheritance of plumage color, which has received a great deal of attention from many investigators.

In the present investigation, it was planned to cross the Ancona with various other breeds to determine its genetic composition, more particularly with regard to plumage and shank color.

The breeds used to cross with the Ancona were the Black Minorca, Black Orpington, White Leghorn, Buff Wyandotte and Light Sussex. All of the birds used in the crosses, with the exception of the Buff Wyandottes, were pedigreed stock from the breeding pens of the University of British Columbia, and all were typical of the breed and variety represented.

Description of Breeds

The Ancona has black plumage with a certain proportion of the feathers tipped with white. The white-tipped feathers are distributed fairly evenly among the solid black feathers, usually at the rate of one white-tipped in from two to five solid black feathers. Pure white feathers sometimes occur among the flight and main tail feathers. The older birds generally appear lighter in color, due to an increase in the size, and possibly in the number of the white tips at each successive moult. This pattern is commonly referred to as mottling. The Ancona has yellow shanks mottled with black. The amount of black present varies, covering a considerable area on the upper part of the shanks on some birds, while on others the shanks are almost free from black.

Both the Black Minorca and Black Orpington have uniform black plumage, black shanks and white soles. The soles of the feet were used as a basis of determining skin color, as in this region there is so little black that it is easy to determine the presence or absence of yellow pigment.

The White Leghorn has pure white plumage and yellow shanks, with no black present.

The Buff Wyandotte has uniform buff plumage with a few black specks in the main tail feathers and in the flight feathers. The shanks are yellow.

The Light Sussex has the "Columbian" pattern, body feathers white, and neck, tail and flight feathers black with white edging. The Light Sussex

differs from some other birds having this color pattern in that the white feathers on the body and wings are usually white throughout, whereas in other "Columbian" breeds the lower part of the feather (undercolor) is a light slate color, described in the American Standard of Perfection (*1*) as "light bluish slate". The shanks and toes are white or pinkish white.

Experimental

The first mating was made in 1925 between a Black Minorca male and an Ancona female. Further matings were made when facilities permitted. Some results of these crosses are presented in the following paragraphs

1. *Crosses of Anconas with Black Breeds.*

Very little was known concerning the hereditary basis of mottling until quite recently. Punnett (*11*) refers to "white spangling such as occurs in Anconas, Spangled Game or Speckled Sussex" and states that the appearance of light spangled birds from a cross between White and Black Rose-comb Bantams, made by Bateson and Punnett (*2*) is intelligible on the assumption that spangling of this kind is dominant to self color. Dunn (*8*) has pointed out that the mottling observed by Bateson and Punnett (*3*) was probably not the same as the mottling of such breeds as the Houdan, and it is likely that this also applies to the "light spangling" referred to in the 1906 report.

Davenport (*4*) found the mottling of the Houdan to be recessive to the solid black plumage of the Black Minorca. Serebrovsky as quoted by Dunn (*8*) found the mottled pattern of Orloffs to be recessive to solid color, but to differ from that of the Houdan, since a cross of these two mottled breeds "produced solid colored progeny."

The results of the crosses of Anconas with Black Minorcas and with Black Orpingtons are set forth in table 1. In this table, the classification of plumage color is based on down color, because this was found to correspond to the color of the adult plumage. The first generation chicks were intermediate with regard to the amount of white showing in the down, between the chicks of the parental race, but, as will be seen by referring to Figure 1, a, b and c, they could readily be distinguished from Ancona pattern chicks. In Figure 1, d and e, are shown in addition to the chicks referred to, the mottled (Ancona) plumage of birds having Ancona pattern down (Fig. 1 a), and the black adult plumage of chicks such as those marked c and d in Figure 1.

The Black Orpington chicks showed more white in the down than did the Black Minorca chicks, but this was not found to make the first generation chicks appear appreciably whiter. The classification of skin color is based on the color of the sole of the foot in the adult. Observations on this point at time of hatching were found to be unreliable, since yellow pigment is frequently observed on the feet of chicks that are entirely free from yellow pigment when mature. The individuals listed under the column "Shank Color not Determined" were those that died or were disposed of before they could be classified.

As set forth in table 1, all the F_1 progeny from the cross of Ancona with Black Minorca and with Black Orpington were black, showing that the solid black plumage of these breeds is dominant to the mottled plumage of the Ancona. There is here no evidence of sex linkage. In the F_2 generation

TABLE 1

Mating No.	Description of Matings	PROGENY									
		BLACK DOWN					ANCONA DOWN				
		White Skin		Yellow Skin		Shank Color Not Determined	White Skin		Yellow Skin		Shank Color Not Determined
		Male	Female	Male	Female		Male	Female	Male	Female	
1 a	Bl. Minorca ♂ × Ancona ♀	14	16								
1 b	Bl. Minorca ♀ × Ancona ♂	17	11								
1 c	F_1 × F_1 from cross Bl. Minorca ♂ × Ancona ♀	9	8	2	5		3	6		1	
1 d	Backcross of F_1 females (from cross Bl. Minorca ♂ × Ancona ♀) to Ancona ♂	7	7	5	1		3	5	5	7	
2 a	Bl. Orpington ♂ × Ancona ♀	5	5								
2 b	Bl. Orpington ♀ × Ancona ♂	4	3								
2 c	F_1 × F_1 from cross Bl. Orpington ♀ × Ancona ♂	4	4	2	3	8	2				2
	Summary of matings 1c and 2c	13	12	4	8	8	5	6		1	2
2 d	Backcross of F_1 females (from cross Bl. Orpington ♂ × Ancona ♀) to Ancona ♂	2	2	-	2	11	1	1	4	3	19
2 e	Backcross of F_1 females (from cross Bl. Orpington ♀ × Ancona ♂) to Ancona ♂	1	2	1	-	13	1	-	2	4	11
	Summary of matings 1d, 2d and 2e	10	11	6	3	24	5	6	11	14	30

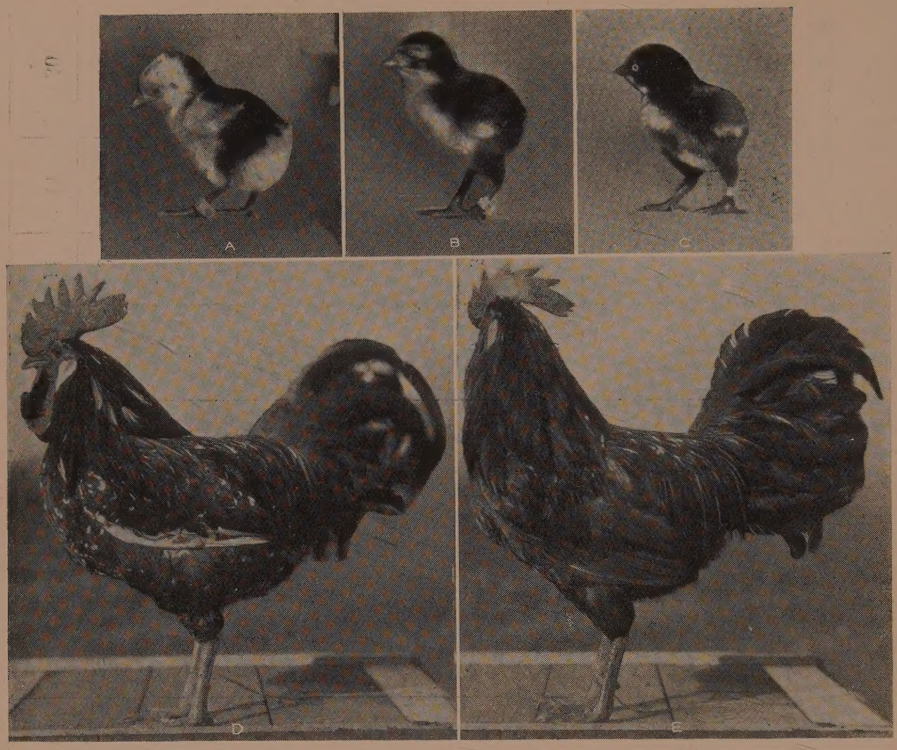


Figure 1. (a) Ancona chick; (b) F_1 Chick from the cross Ancona × Black Minorca; (c) Black Minorca chick; (d) Mottled and (e) black F_2 males from the cross Ancona × Black Minorca.

(see matings 1c and 2c) there were 45 chicks with black down to 14 with mottled (Ancona) pattern, which closely approximates a three to one ratio. The results of these matings indicate a difference determined by a single autosomal gene, which may be designated E^1, the constitution of the Ancona being e^1e^1.

Backcross matings (1d, 2d and 2e) made to the Ancona parent gave slightly varying results. From matings 1d and 2e the expected equality of numbers of black and Ancona pattern chicks was obtained, viz. 20:20 and 17:18 respectively, whilst from mating 2d, the proportion obtained was 17 black to 28 Ancona pattern. This departure from the expected ratio is probably not significant.

The inheritance of shank and skin color has been investigated by Dunn (*7*), Lambert and Knox (*10*), Dunn and Jull (*9*) and others. All of these investigators found that white skin color was dominant to yellow, and that the difference was determined by a single autosomal gene. The results shown in table 1 of this report agree with these findings.

The data for the backcross matings give some evidence of linkage between black plumage and white skin color and between mottled (Ancona pattern) plumage and yellow skin color. No such linkage is, however, indicated by the data for the F_2 generation; hence, the apparent linkage cannot be considered significant.

The original black parents all had fully black shanks, while the F_1 birds had bluish black shanks. In the F_2 generation the black plumaged birds had fully black shanks, the exact shade depending on whether yellow pigment was or was not present and on whether the bird was homozygous or heterozygous for the gene determining the presence of black in the shanks. Warren (*13*) has pointed out that the factors for certain plumage colors also appear to affect the shank color. In the present series of crosses between the Ancona and the Black Minorca and Black Orpington, it was found that the shank color corresponded to the plumage color, the birds with solid black plumage having shanks of solid black, bluish black or greenish black, while those with mottled plumage had white or yellow shanks mottled with black. The evidence from these crosses would, therefore, seem to indicate that in this case the factor determining the distribution of black in the plumage also determines the distribution of black in the shanks.

2. *Crosses of Anconas with White Leghorns.*

It has repeatedly been shown (see Punnett, (*11*)) that the white plumage color of the White Leghorn depends on a dominant autosomal gene (I) which inhibits the production of melanic pigment. It has further been demonstrated that the White Leghorn carries the sex-linked gene (B) for barring and there is some evidence to indicate that the absence of black in the plumage depends partly on the presence of this gene. The evidence for this view is discussed by Punnett, (*loc. cit.*). In addition to the two genes referred to, the White Leghorn has the gene for ground color, commonly designated by C, which is supposedly the same as that responsible for the black color of the plumage of such breeds as the Black Minorca, Black Orpington and Ancona.

The original mating made was a cross between an Ancona male and White Leghorn females. The results of this cross with regard to plumage color are set forth in table 2. All of the 21 first generation chicks were white, with small flecks of black in the plumage. In the F_2 generation 51 of the chicks were white and 20 colored, which agrees fairly well with the numbers expected (53.25 white to 17.75 colored) on the basis of a one-factor difference. The number of white chicks obtained from the backcross matings was equal to the number of colored chicks, thus agreeing exactly with expectation.

The distribution of the colored chicks is interesting. Basing the classification on down colors, there were 6 black, 4 barred and 10 Ancona pattern chicks, representing an apparent excess of the last named class. Of these 20 chicks, 12 survived and were classified on the basis of adult plumage. Three of these were black, one mottled, four barred and four light-barred. Those described as "light-barred" were all males. They were barred in all sections except the flight feathers and main tail feathers, which were white (Fig. 2b). This lighter effect was obviously caused by a combination of the genes for mottling and for barring. A similar effect has been reported by Punnett and Pease (*12*).

Of the four "pied" pullets illustrated in Plate X. accompanying their report, two are barred and two unbarred. The two barred pullets, show

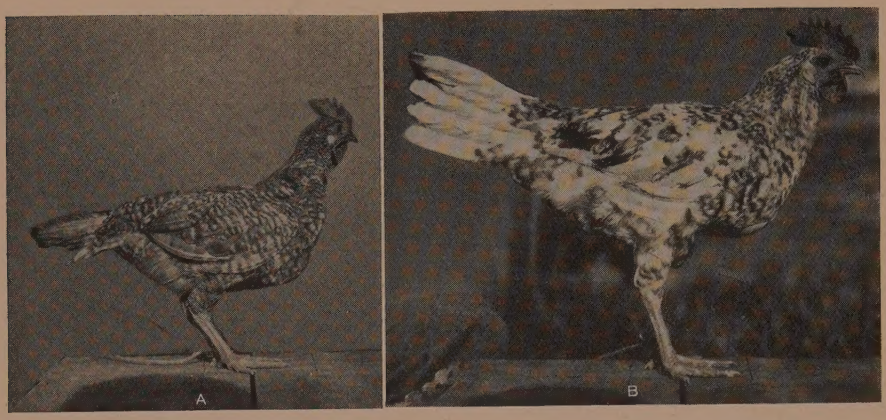


Figure 2. (a) Barred and (b) Light barred males from the cross Ancona × White Leghorn.

more white in the plumage than the corresponding unbarred pullets, but resemble them in outward appearance. In the case of the present cross, the effect is also to increase the proportion of white on the plumage, but the predominant pattern is barring rather than mottling.

Pied plumage is described as a mixture of colored, parti-colored and pure white feathers. While white feathers occur in the plumage of Anconas, such feathers are comparatively rare. This is apparently the chief difference between the adult plumage of pied and mottled (Ancona) birds. The down color of the pied and mottled birds is partically the same. Punnett and Pease (*loc. cit.*) found that chicks from pied birds which were also known to carry the factor for barring, could not be distinguished from unbarred chicks by the white occipital head spot which differentiates chicks of barred breeds from chicks of self-black breeds, since all had the down pattern of typical "pied" chicks. All the birds described above as light barred had Ancona (mottled) pattern down when hatched and were in no way different from those that later developed into birds having typical mottled (Ancona) plumage.

The marked resemblance in the down pattern of pied and mottled birds and in the effect on the down color of the chicks of factors introduced by such birds when crossed with barred birds may indicate that they are genetically alike with respect to a factor or factors, governing down pattern. It may further be noted that the plumage pattern of both behaves as a simple recessive to self-black plumage. The differences set forth above are such, however, as to show that pied birds are genetically different from mottled birds with respect to one or more factors governing plumage pattern. For this reason the symbols e^1e^1 are here used for the Ancona and E^1E^1 for the self-black breeds, instead of the symbols ee and EE used by Punnett and Pease (*loc. cit.*) for pied and self-black birds.

Further matings have been made to determine the factorial relations that produce light barring. The results obtained will be reported later.

TABLE 2

Description of Matings		PROGENY				
		White	Black	Ancona (Motteled)	Barred	Light Barred
Ancona ♂ × White Leghorn ♀		21				
F_1 × F_1 from cross Ancona ♂ × White Leghorn ♀	Down Color	51	6	10	4	
	Adult plumage	20	3	1	4	4
Backcross of F_1 females (from cross Ancona ♂ × White Leghorn ♀) to Ancona ♂	Down Color	9	2	7		
	Adult plumage	6	2	4		

TABLE 3

Description of Matings	PROGENY			
	Silver		Gold	
	Male	Female	Male	Female
Ancona ♂ × Buff Wyandotte ♀	3	3		
Ancona ♀ × Buff Wyandotte ♂	4			5
F_1 × F_1 from the cross Ancona ♂ × Buff Wyandotte ♀	9	7		5
F_1 × F_1 from the cross Ancona ♀ × Buff Wyandotte ♂	7	5	7	8

The results from the backcross of the F_1 females to Ancona male agree with expectation so far as the distribution of the colored chicks is concerned, no barred chicks being obtained (table 2). There is an excess of Ancona pattern chicks over solid black pattern chicks, but since the numbers are small, no significance can be attached to this result.

3. *Crosses of Anconas with Buff Wyandotte.*

The cross with the Buff Wyandotte was made primarily to determine whether the Ancona carried the dominant, sex-linked "silver" gene, the Buff Wyandotte, like all "buff" breeds, being known to carry the recessive "gold" gene. The results of this cross with regard to the silver (S) and the gold (s) genes are set forth in table 3. The classification of the first generation was based on down colors, but that of the second generation was based on adult plumage except in a few cases where observations on three months old birds were used. Certain black plumaged birds were omitted as it was not possible to classify them by appearance as silvers and golds.

The six first generation birds from the Ancona male mated to Buff Wyandotte female were all silvers while of the nine birds obtained from the reciprocal cross (Buff Wyandotte ♂ × Ancona ♀) the four males were silvers and the five females were golds, thus showing that the Ancona carries the silver gene (see Fig. 3).

The distribution of the golds and silvers in the F_2 generation, from the cross of Ancona male mated to Buff Wyandotte female, also agrees with expectation, all of the golds being females. The number, 5 out of 21 (5 golds to 16 silvers) also agrees with the expected number of one in four.

In the F_2 generation from the reciprocal cross (Buff Wyandotte ♂ × Ancona ♀) a ratio of 12 silvers to 15 golds was obtained which agrees reasonably well with the expected 1 : 1 ratio. Moreover, the four classes (silver males, silver females, gold males, and gold females) are all represented by about the same number of individuals.

None of the F_2 generation birds raised had the typical Ancona plumage, hence, it is not advisable at this time to attempt a complete analysis of these two breeds with regard to the genes that differentiate their plumage color. Some of the results of this cross, in addition to those shown in table 3, may, however, be discussed at this time.

The Buff Wyandotte carries a certain amount of black in the plumage. Dunn (*5, 6*) has shown that this black actually indicates the presence of the gene which he calls e^m. This gene according to Dunn (*loc. cit.*) restricts black to the neck hackle, flights and main tail feathers. In the case of the Buff Wyandotte the black in these sections is absent or very much restricted, probably due, according to Dunn (*6*) to the action of multiple factors which restrict the development of black in these sections.

The data obtained in the present investigation support Dunn's (*6*) findings that the gene e^m is autosomal. Whichever way the cross was made, the first generation birds, both males females, silvers and golds, had the same or similar plumage pattern. There was somewhat more black in the surface

color of the females, but this was not nearly so marked as in the case of the cross reported by Dunn (*6*).

All of the first generation birds had black extended to other sections than the neck hackle, flights and main tail feathers and would on that basis be classified as non-columbian. When the F_2 generation birds are classified as columbian or non-columbian, that is, according to whether the black is restricted to the neck hackle, tail and flight feathers or whether it is extended to other sections, the distribution is as follows:

	Non-columbian	Columbian
F_2 from Ancona ♂ × Buff Wyandotte ♀	17	7
F_2 " " ♀ × " " ♂	19	8
Total obtained	36	15
Total expected	38.25	12.75

The numbers obtained agree fairly well with the numbers expected on the basis of a one factor difference.

Birds having the typical columbian pattern not only have the black restricted to certain sections but the distribution of the black in these sections is also fairly constant and typical of birds having this pattern. Thus, the neck hackle feathers are generally black with a lighter edging. Even where genes are introduced which extend black, this pattern of the neck hackle is still in evidence.

In the present cross all the first generation birds showed the striping observed in breeds having the columbian pattern. In the F_2 generation the distributon of striped and non-striped birds was as follows:

	Striped	Non-striped
F_2 from Ancona ♂ × Buff Wyandotte ♀	19	8
F_2 " " ♀ × " " ♂	18	6
Totals	37	14

Approximately, two-thirds of the birds classified as non-columbian above showed the striping of the neck hackle. There is some evidence here to show that the striping of the neck hackle indicates the presence of the e^m gene, although it must be recognized that birds carrying the e^m gene do not always show striping. This is true of the Buff Wyandotte and was also true of certain birds among the F_2 generation, which were white except for grey in the tail feathers. In the present case, it appears that while all the birds that carry the e^m gene do not show striping, all those that did show striping carry this gene. This may indicate that the numerous color patterns of poultry, of which striping of the neck hackle is a part are produced by a combination of the gene e^m with other genes affecting plumage pattern.

There is another point in connection with the interaction of the genes affecting plumage color introduced by the Ancona and the Buff Wyandotte which may be noted at this time. The first generation birds obtained by Dunn (*6*) from a cross of black and columbian fowls had more black in the surface color than the first generation birds from the cross of Ancona × Buff Wyan-

dotte, the latter being, as noted before, a columbian breed. There are two possible explanations of the lighter color of the F_1 progeny from the Ancona $\times$ Buff Wyandotte cross as compared with those obtained by Dunn (*loc. cit.*). One explanation is that the gene e^1 (Ancona pattern) when combined with the gene e^m (columbian pattern), tends to restrict black, an effect similar to its interaction with the gene B for barring. The other possibility is that the gene or genes which restrict black in the Buff Wyandotte are responsible for the lighter color. This was tested by mating the Ancona with the Light Sussex, the latter having the typical columbian pattern. The first generation males from this cross were quite similar to those obtained by Dunn, which he designated as duckwing males. There was more black in the surface color of these males than in those from the Ancona $\times$ Buff Wyandotte cross.

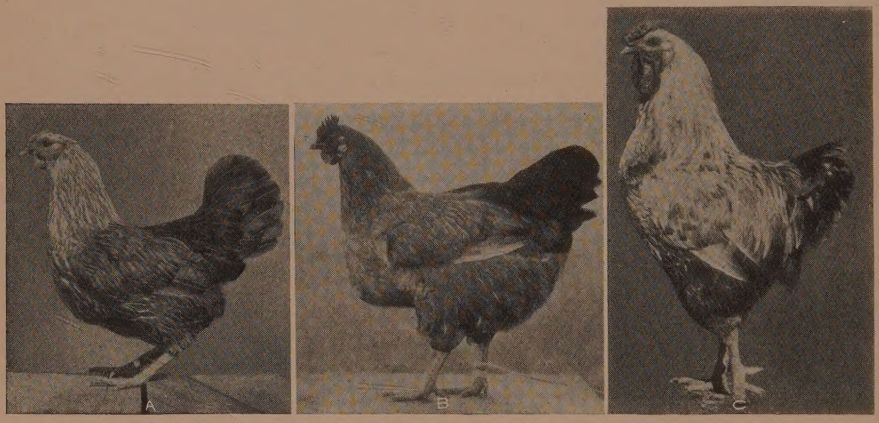


Figure 3. (a) F_1 Silver female from the cross Ancona ♂ $\times$ Buff Wyandotte ♀; (b) F_1 gold female from the cross Buff Wyandotte $\times$ Ancona; (c) F_1 silver male from the cross Ancona $\times$ Buff Wyandotte.

The first generation females from the Ancona $\times$ Light Sussex cross resemble the Birchen females obtained by Dunn (*6*) and are considerably darker than the first generation females from the Ancona $\times$ Buff Wyandotte cross. One of the lightest colored of the first generation females from the Ancona $\times$ Light Sussex cross is shown in Figure 4 for comparison with those from the Ancona $\times$ Buff Wyandotte cross (Fig. 3a). The evidence from these two crosses indicates that the lighter color of the first generation from the latter cross is due to genes contributed by the Buff Wyandotte parents.

4. *Constitution of the Ancona.*

In the crosses discussed above, evidence was obtained on the genetic composition of the Ancona with regard to a number of genes affecting plumage color. Serebrovsky (Dunn (*8*)) has demonstrated the presence of two genes for color, one of which is commonly designated C. The composition of the Ancona with regard to this gene and the others discussed in connection

Figure 4. F_1 female from the cross Ancona × Light Sussex.

with the various crosses may be set forth, using the conventional symbols, as follows:

Ancona male—$CCe^{l}e^{l}E^{m}E^{m}bbSSii$
Ancona female—$CCe^{l}e^{l}E^{m}E^{m}b–S–ii$

The gene designated here as e^{l} which determines the mottling of the plumage of the Ancona apparently corresponds to one of the genes that Serebrovsky (Dunn, (*6*)) found in the mottled breeds with which he worked. The Ancona, according to Serebrovsky's classification, would be designated "atrase".

The presence of other genes affecting plumage color is indicated by the results of the Ancona × Buff Wyandotte cross. More data are required, however, before they can be satisfactorily identified.

Summary

The Ancona was crossed with Black Minorcas, Black Orpingtons, White Leghorns, Buff Wyandottes and Light Sussex.

Mottled (Ancona) plumage behaved as a simple recessive to solid black plumage. The results of crossing the Ancona with the Black Minorcas and Black Orpingtons can be explained on the basis of a single autosomal gene designed E^{l}.

The yellow skin color of the Ancona was found to be recessive to white skin color, the difference being determined by a single autosomal gene.

The mottled plumage color of the Ancona behaved as a simple recessive to the white plumage color of the White Leghorn. In the F_2 generation from this cross certain individuals, described as light barred, appeared due to the interaction of the gene e^{l} for mottling with the gene B for barring.

The Ancona carries the sex-linked silver gene (S).

The Ancona carries the dominant allelomorph of the gene e^{m} which restricts black to certain sections in columbian pattern breeds.

The first generation birds from the cross of Ancona × Buff Wyandotte were lighter in color (had less black in the surface color) than the first

generation birds from the cross Ancona × Light Sussex. This result is apparently attributable to the action of the same genes that restrict black in the Buff Wyandotte.

LITERATURE CITED

1. American Poultry Association, Standard of Perfection. 1923.
2. Bateson, W. and Punnett, R. C. Experimental studies in the physiology of heredity. Poultry. Reports to the Evolution Committee of the Royal Society iii. 1906.
3. ———————————. Experimental studies in the physiology of heredity. Poultry. Reports to the Evolution Committee of the Royal Society. iv. 1908.
4. Davenport, C. B. Inheritance in poultry. Public. No. 52, Carnegie Institution of Washington. 1906.
5. Dunn, L. C. A gene for the extension of black pigment in domestic fowls. Amer. Nat. *56*: 464. 1922.
6. ————————. Color inheritance in fowls. The genetic relationship of the black, buff and columbian coloration in fowls. Jour. Her. *14*: 23-32. 1923.
7. ————————. The genetic relation of some shank colors of the domestic fowl. Anat. Rec. *31*: 343-344. 1925.
8. ————————. Abstract of "Studies on genetics of domestic fowl" by Serebrovsky, A.S., Jour. Her. *19*: 511-519. 1928.
9. ———————— and Jull, M. A. On the inheritance of some characters of the silky fowl. Jour. Gen. *19*: 27-33. 1928.
10. Lambert, W. V. and Knox, C. W. Genetic studies in poultry, 11. The inheritance of skin color. Poultry Sci. *7*: 24-30. 1927.
11. Punnett, R. C. Heredity in poultry. 1923.
12. ———————— and Pease, M. S. Genetic studies in poultry, V–On a case of pied plumage. Jour. Gen. *18*: 207-218. 1927.
13. Warren, D. C. Sex-linked characters of poultry. Genetics, *13*: 421-433. 1928.

THE DETERMINATION OF THE ANTI-RACHITIC PROPERTIES OF OAT OIL *

L. A. Munro and W. J. Rae†
Manitoba Agricultural College, Winnipeg, Man.
[Received for publication July 2, 1929]

The cereals have never been considered a source of Vitamin D. It is therefore to be expected that the oils extracted from the grains would show a deficiency of this vitamin. It was found, however, (*1*) that linseed, cottonseed, and other vegetable oils, when exposed to ultra violet radiation became activated. A ration containing as little as 0.2 per cent of irradiated oil was found to protect experimental animals from rickets (*2*). Subsequent investigations showed that this anti-rachitic property was associated with the unsaponifiable matter in the oil. Hess (*3*) and his co-workers Steenbock (*2*) and others, found that the sterols, particularly cholosterol, phytosterol and ergosterol, gave a very potent anti-rachitic action.

Steenbock and Black (*2*) found that old oils could not be activated by irradiation. They used samples of cocoanut oil seven years old, corn oil and cottonseed ten years of age, peanut and oleo oils that had been stored for six years. In all cases no activity was obtained on thirty minutes' irradiation. An unrefined sample of cocoanut oil kept for two years did become active on exposure to the ultra violet for the same length of time.

The chemical and physical constants of oat oil prepared on a large scale were determined by Munro and Binnington (*5*). This oil gave a high value for unsaponifiable matter.

Since a quantity of this oil had been kept in sealed containers for a year, it was thought advisable to investigate the possibility of activating the old oil by exposure to ultra violet.

An experiment was planned to compare the anti-rachitic effect of irradiated and unirradiated oat oil with cod liver oil and direct sunlight. The experiment also included an investigation of the vitamin D content of fish meal and a comparison of the protein efficiency of this food with that of dried skim milk.

The experimental animals used in this investigation were White Leghorn chicks. These were divided at time of hatching into six pens, thirty chicks to a pen, having similar brooder conditions. The light was admitted to each pen, with one exception, through ordinary window glass.

A basal dry-mash ration was fed. This consisted of: 48% yellow corn meal, 20% wheat middlings, 5% wheat bran, 2.5% bone meal, 2.5% calcium carbonate, 0.5% sodium chloride, 20% dried skim milk and 2% corn oil. The corn oil was added so that the fat content of the ration of each pen would be comparable. This ration is essentially the same as that used by Hart, Steenbock and Lepkovsky (*6*) with the exception of the addition of the phosphate in the form of bone meal. It is deficient in the anti-rachitic factor, Vitamin D.

*Presented at the Canadian Chemical Convention, Toronto, May, 1929.
†Assistant Professor of Chemistry and Lecturer in Poultry Husbandry, respectively.

The treatments given the pens were as follows:

Pen. 1. Controls—basal ration only.
" 2. 1% Corn oil, replaced by an equal weight of C.L.O.
" 3. All of the corn oil replaced by oat oil.
" 4. Same as pen 3, except that the oat oil was irradiated, by exposing it, in a thin film, to a mercury quartz lamp at a distance of 24 in. for fifteen minutes.
" 5. Direct sunlight through an open window.
" 6. In this pen dried skim milk was replaced by an equivalent amount of fish meal, to give the same protein balance as in other pens.

The experiment extended over a period of fourteen weeks. No appreciable difference was observed for the first six weeks. Leg weakness appeared in pens 1, 3 and 4 after the sixth week, and in pen 6 at the eighth week. Apparently the irradiated oat oil had no anti-rachitic value. Individual chicks were weighed from the fifth week on. Growth curves for the different pens are shown in figures 1 and 2. In these the average weekly weights of cockerels and pullets are plotted separately because of the differential rate of growth of the two sexes.

It will be seen that the curves draw apart rapidly after the eighth week. In both figures pen 5, which received direct sunlight, gives growth curves that lie above the other curves, after the seventh week. The curves for pen 2 lie above the remaining pens after the tenth week. The pen receiving fish meal as its source of protein was appreciably slower in rate of growth than any of the other pens throughout the whole experiment. This points to the conclusion that the nutritional qualities of the proteins in this sample of fish meal are inferior to those of dried skim milk, or it may be that the relatively large amount of fish meal fed exerts a definite toxic effect, although the mortality in the pen was very low, even less than that in the cod liver oil pen.

TABLE NO. 1

Pen	Cockerels		Pullets	
	Mean Weight	Diff/P.E.	Mean Weight	Diff/P.E.
1. Control	699.96 ± 14.43		603.29 ± 19.19	
2. C.L.O.	848.51 ± 16.46	6.72	613.21 ± 20.10	.402
3. O. Oil	684.10 ± 18.30	.603	582.88 ± 19.98	.833
4. Ir. O.O.	654.10 ± 14.73	2.15	536.10 ± 24.73	2.35
5. Sun	917.45 ± 24.09	7.54	717.26 ± 19.38	4.74
6. Fish M.	589.68 ± 23.53	3.99	488.75 ± 19.36	4.77

Table 1 gives the mean weights of each pen at the end of the thirteenth week, and shows the significance of the data. From the calculations it appears that there is no significant difference between the growth of the oat oil pens and the controls. With both cockerels and pullets there is a significant difference between pens 5 and 6 and the controls. Most investigators have not separated their results for the cockerels and pullets. If the average weight of the whole pen is taken there would be a significant difference between the cod liver oil pen and the control. Our calculations based on the weights of the pullets and cockerels taken separately show a significant difference for the cockerels, but not for the pullets. We hesitate to suggest an explanation without further experimental data.

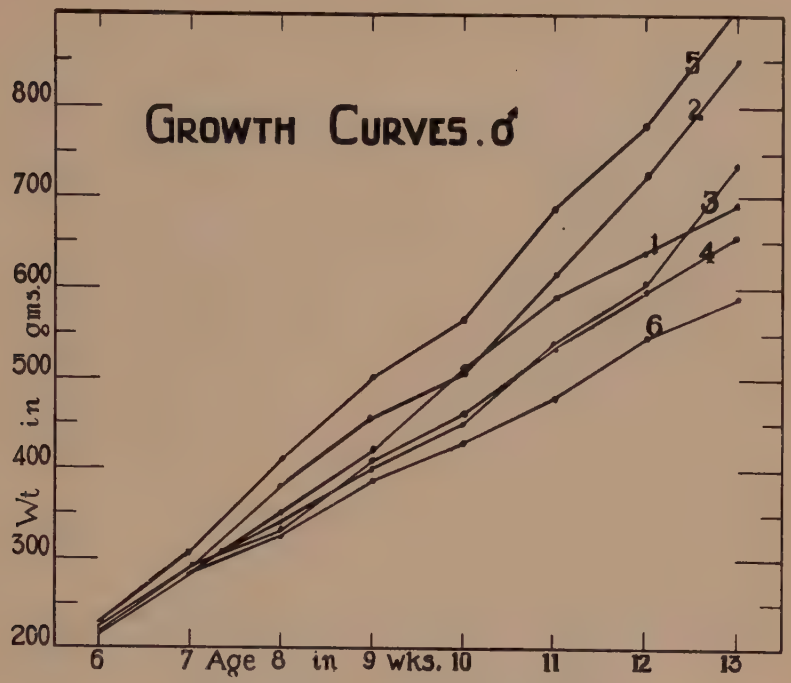


Figure 1. Growth curves for cockerels.

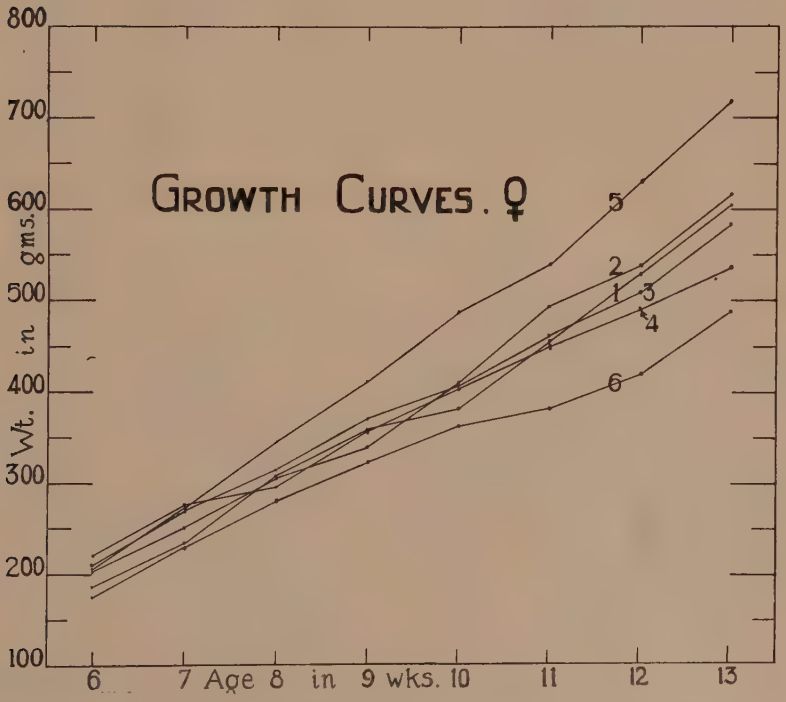


Figure 2. Growth curves for pullets.

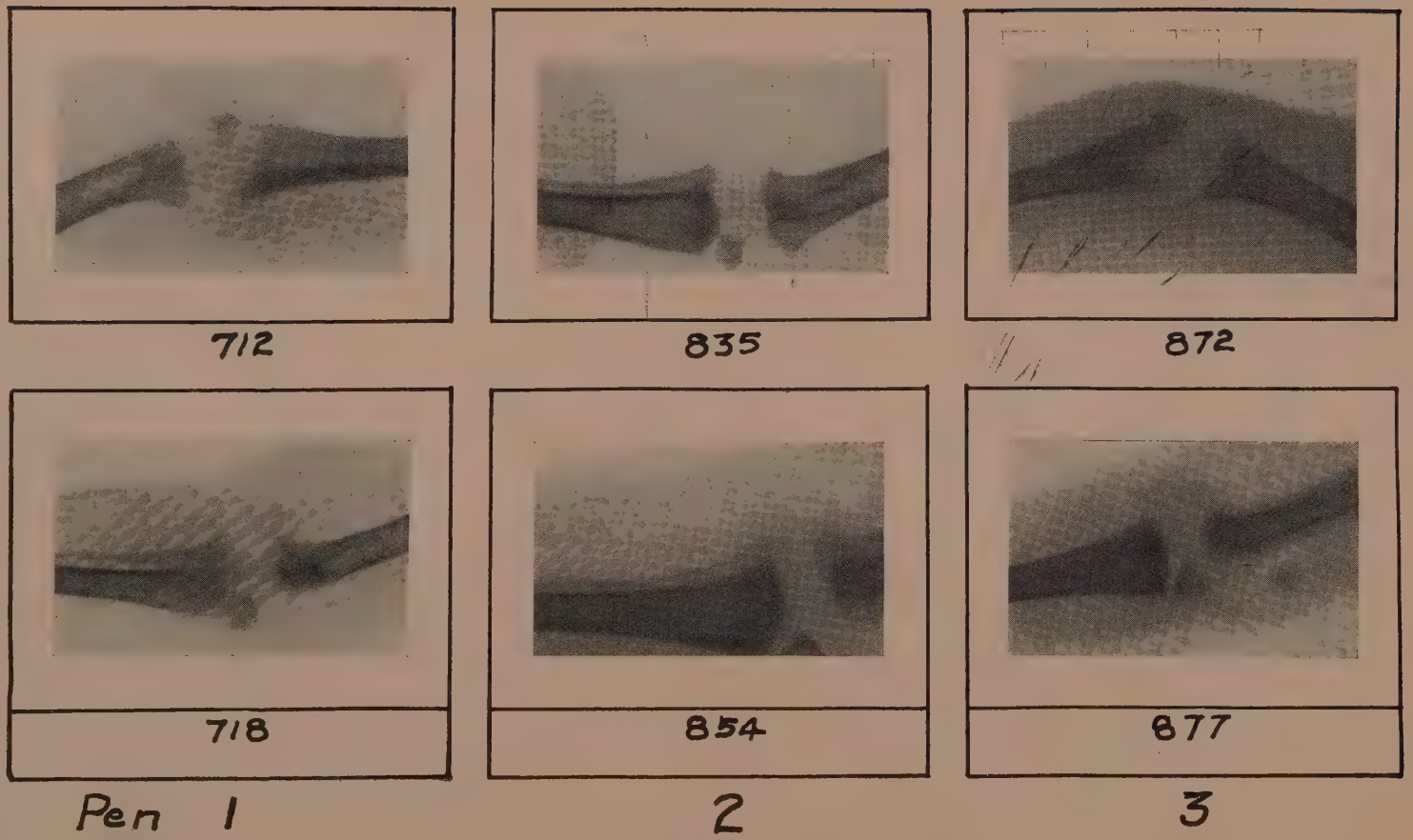


Figure 3.

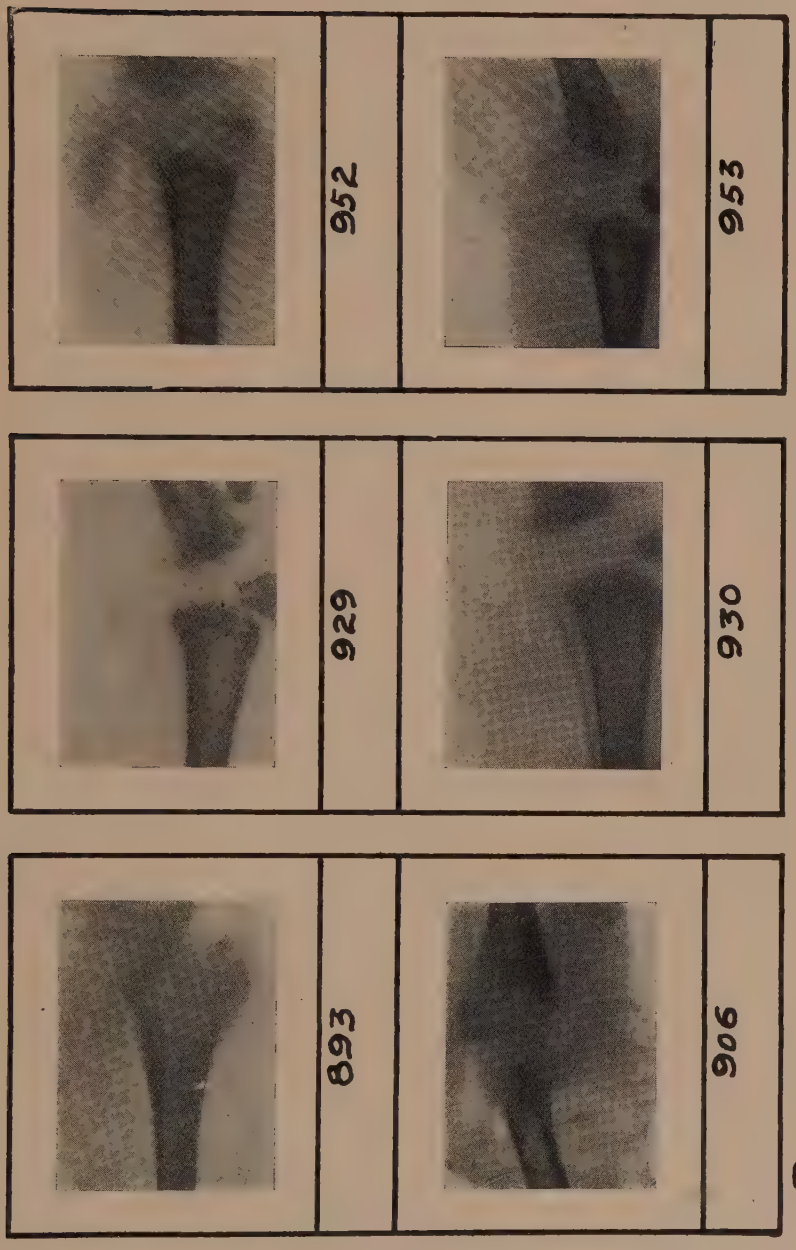


Figure 4.

The inactivity of the oat oil in preventing rickets as shown by the growth curves and by observations of leg weakness, is also demonstrated by examination of the bones of representative birds. A cockerel and pullet were taken from each pen. In selecting birds care was taken that the individuals were not from the worst or best in the pen. Figures 3 and 4 show X-ray photographs of the articulations of the tibia and metatarsus of twelve week old birds.

It will be noticed that the outline of the bones is much sharper in the case of pens No. 2 and No. 5 than in any of the others. In pens No. 1, No. 3 and No. 4, the ends of the bones are very poorly defined, showing very slight calcification. In pen No. 6 the bones seem better formed than one might expect from the growth curves, although the distance between the bones, representing cartilage, is larger than in No. 2 or No. 5.

A macroscopic examination of the tibia of chicks from different pens is of interest. Figs. 5 and 6 show in a striking way, the effect of vitamin D on the height of the individual. Each pair represents the tibia of a cockerel and pullet fourteen weeks of age.

Those for pens No. 2 and No. 5 are much longer than the others. If human bones were affected in a similar ratio, the difference in the length of the tibiae represented by No. 5 and No. 1 would be about two inches.

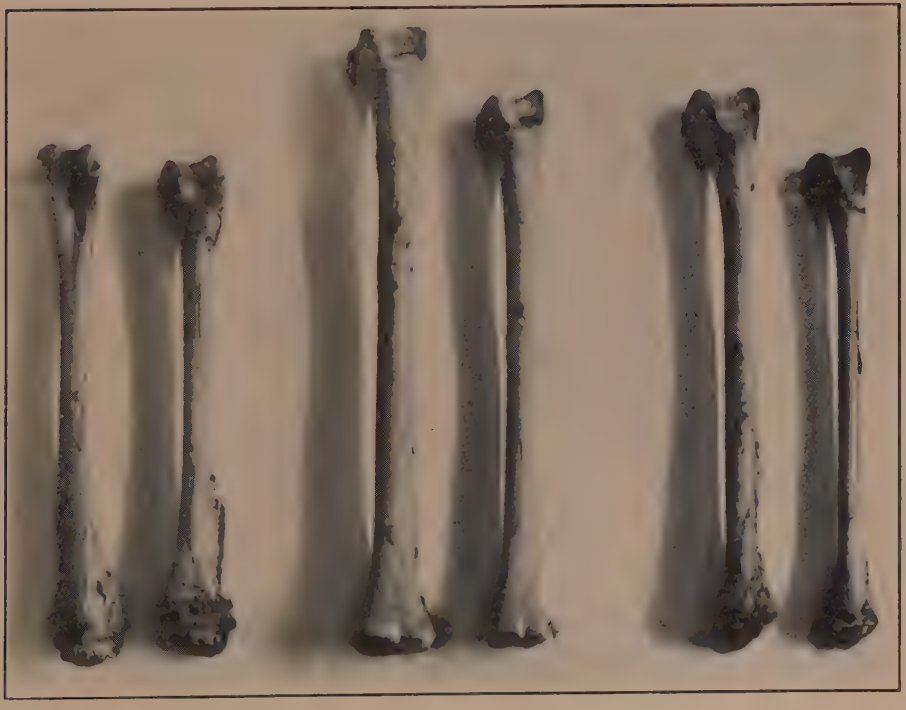
The photographic evidence is confirmed by a determination of the bone ash. The bones were extracted with alcohol for three days and then dried at 110°C. for two days. The percentage of ash in the bones of chickens 12 weeks of age will be found in table 2. The average value for birds from each pen is found to give the same result as the photographs. The table also includes a determination of the amount of ash in the blood of representative birds. These were bled directly into small beakers packed in ice and salt. As soon as chilled, it was transferred into a weighed silica ash dish, and the amount of blood determined by weighing in a moist atmosphere. By this method very little was lost by evaporation and the average values obtained for the different pens agree surprisingly well with the results obtained for the ash content of the bones.

Table 3 gives the ash content of the tibia of birds fourteen weeks of age. These results are similar to those of table 2, pen No. 5 being markedly above all the others in the percentage of ash.

It has been noted that excessive radiation of cod liver oil and olive oil produced inactivation. Steenbock and Black used exposures of 30 minutes, 5 hours, 10 hours and 17 hours at a distance of 24 inches. Exposures of five hours and over gave inactivation. Recently Knudson and Moore (*4*) noted that ergosterol exposed for 15 seconds is more active than when exposed for 30 minutes. In this case the distance from the mercury lamp was only 18 cm. or a little over 7 inches. This exposure would correspond to an exposure of over four hours at the distance used in our experiment.

Pen 1 Pen 2 Pen 3

Figure 5. Tibia from representative birds in pens 1, 2 and 3.



Pen 4 Pen 5 Pen 6

Figure 6. Tibia from representative birds in pens 4, 5 and 6.

TABLE 2. *Ash content of tibia and blood, of twelve week old chicks*

Pen	Sex	Weight of Tibia	Weight of Bone Ash	%	Mean	% Ash in Blood
No 1	C	2.2565g.	0.973g.	43.12		
(Control)	P	1.4724	0.3842	39.68	41.5	0.95
No 2	C	2.8217	1.2718	48.62		
(C.L.O.)	P	2.0681	0.9121	44.10	46.4	0.99
No 3	C	2.3843	0.9426	39.53		
(O.O)	P	1.7172	0.7336	42.72	41.1	0.93
No 4	C	2.5726	0.9243	35.54		
(R.O.O.)	P	1.9489	0.7955	40.82	38.2	0.95
No 5	C	3.5160	1.6738	47.61		
(D. Sun)	P	2.6415	1.2298	46.56	47.1	1.02
No 6	C	2.5975	1.0308	39.68		
(F.M.)	P	1.6820	0.6343	38.96	39.3	0.93

TABLE 3. *Ash content of the tibia of fourteen week old chicks*

Pen	Sex	Weight of Tibia	Weight of Bone Ash	%	% Mean for Pen
No 1	C	3.0589g.	1.1675g.	38.17	
(Control)	P	2.4060	1.0711	44.52	41.4
No 2	C	3.8412	1.6427	42.77	
(C.L.O.)	P	3.0258	1.7018	56.77	49.8
No 3 *	C	3.2658	1.3484	41.29	41.3
No 4	C	3.4764	1.5469	44.50	
(R.O.O.)	P	2.6560	1.2483	47.00	45.8
No 5	C	4.8641	2.8023	57.61	
(D. Sun)	P	2.7189	1.4993	56.14	56.4
No 6	C	2.9135	1.1000	35.56	
(F.M.	P	2.2679	1.0331	45.55	42.2

*Only one bird from pen three.

It is very improbable that the inactivity of the irradiated oat oil was due to over exposure since the power of the lamp, distance, and length of exposure are comparable with those used with good results for the activation of other oils.

SUMMARY

1. An investigatinon was made of the anti-rachitic properties of irradiated and non-irradiated oat oil that had been kept in stoppered and sealed bottles for a year.
2. The growth curves, size of bones, X-ray photographs of joints, and ash determinations of bones and blood show that the sample used had no anti-rachitic effect before or after irradiation.
3. A commercial sample of fish meal, when substituted for milk protein, gives a decrease in rate of growth.

LITERATURE CITED

1. HESS, A. F. Amer. Jour. Dis. of Children. *28*: 517, 1924.
2. STEENBOCK, H. and BLACK, A. Jour. Dio. Chem. *64*: 263, 1925.
3. HESS, A. F., WEINSTOCK, M. and HELMAN, F. D. Proc. Soc. Exper. Biol. Med. *22*: 237-8, 1925.
4. KNUDSON, F. and MOORE, J. Jour. Biol. Chem. *81*: 55. 1929.
5. MUNRO, L. A. and BINNINGTON, D. Indust. and Eng. Chem. *20*: 425. 1928.
6. HART, E. B., STEENBOCK, H. and LEPHOVSKY, S. Jour. Biol. Chem. *65*: 571. 1925.

SOME ASPECTS OF POLYPLOIDY IN RELATION TO THE THE CEREAL CROPS *

C. Leonard Huskins

John Innes Horticultural Institution, Merton Park, London, England.

The basic chromosome number of the four small grain crops, wheat, barley, oats and rye, is seven. Rye and all the cereal barleys have 14 chromosomes as their body cell or diploid number (†). Both wheat and oats fall into three distinct groups: diploid species with 14 chromosomes, tetraploid species with 28, and hexaploid species with 42 chromosomes. Three of the diploid species of oats, *Avena brevis, A. strigosa* and *A. nuda brevis* have definite though limited agricultural value; a fourth, *A. Wiestii,* and the diploid wheat *Triticum monococcum,* are of practically no direct economic importance. Two of the tetraploid wheat species, *T. durum* and *T. turgidum* include some very important agricultural varieties, but *T. polonicum, T. dicoccum, T. persicum* and the wild *T. dicoccoides* have very limited economic value. It is in the hexaploid group with 42 chromosomes that the agriculturally important species *T. vulgare, T. compactum, A. sativa,* and *A. byzantina* occur, though this group contains also the relatively unimportant *T. Spelta,* and both the common wild oat *A. fatua* and the Mediterranean wild oat *A. sterilis.*

It is obvious, of course, that the chromosome number in itself does not determine the agricultural value of cereal species, but it seems equally clear that replication of the chromosome number, or polyploidy, has played a large part in the evolution of the species of wheat and oats most important in agriculture. In the short time at our disposal this afternoon I should like to mention some of the features of the cereals which seem to me to be associated with their polyploid nature. It is, however, necessary first to stress the type of polyploidy which seems chiefly to have been involved.

Types of Polyploidy

As previous speakers have mentioned, chromosome doubling in a sterile hybrid, allopolyploidy, has in a number of instances produced fertile forms which have many claims to rank as new species. They may breed relatively true to type, may be as fertile as either of the original species from which they arose, and may retain the hybrid vigour of their immediate parent. On the other hand, autopolyploidy or chromosome doubling which is not preceded by hybridisation between distinct species, may produce giant forms, but they are rarely if ever as fertile as the original form. The so-called 'tetraploid ratios' 35:1 and 5:1 (instead of the mendelian ratios 3:1 and 1:1) are obtained from autopolyploids on selfing and back-crossing respectively. These ratios result from the free association and assortment of factors present in quadruplicate on account of the chromosome doubling.

*Paper read at a Conference on Polyploidy held on January 19, 1929, at the John Innes Horticultural Institution, Merton Park, London, to commemorate the centenary of the birth of the founder, the late Mr. John Innes.

†In the genus *Hordeum* there are species with 14, 28 and 42 chromosomes The relationship of the wild species with 28 and 42 chromosomes to the cultivated species is, however, apparently very remote. The occurrence of a strain of rye with 16 chromosomes has been found to be due to iragmentation of one pair.

The hexaploid species of wheat and oats behave ordinarily, both cytologically and genetically, like simple diploids; that is, their 42 chromosomes form 21 pairs in germ cell formation, and after crossing their segregation for most characters is in ratios which are determined by the association and assortment of factors in pairs. As will be shown in detail later, they often have similar pairs of factors present more than once, but these do not give tetraploid ratios. If, for example, a white variety of oats is crossed with one having two factors for black glume colour, the black and white progeny of the second generation appear in the ratio of 15:1 (which results from the independent segregation of two pairs of factors) and not 35:1, as they would if the factors were on four chromosomes which mated freely *inter se* at germ cell formation.

Many workers with cereals have assumed that the hexaploid species have arisen through the replication of the chromosome set of one original diploid species, that is, by autopolyploidy, and that the present wide diversity of the hexaploid cereals, as well as the differentiation of their chromosomes which causes them to form 21 pairs instead of seven sets of six, has been brought about by gene mutation subsequent to the doubling. In my opinion there is practically no evidence for this assumption. On the other hand their diversity and behaviour are just what would be expected if they have arisen by allopolyploidy. The hexaploid species have probably arisen by two steps. First the hybridisation of two diploid species followed by chromosome doubling to produce a tetraploid, and then the hybridisation of this or similar tetraploids with diploids, again followed by chromosome doubling to produce hexaploids. This will be discussed further after some of the evidence has been presented.

Polymeric Factors

An interesting feature of crosses between hexaploid species of wheat or oats has been the discovery of many cases of duplicate or polymeric factors. Nilsson-Ehle and others have found, for instance, that different varieties of wheat may have 1, 2 or 3 pairs of factors for red colour of the grain. Ackerman (*1*) has shown that three independent pairs of factors affect chlorophyll development in oats. In wheat it appears that head-type, dwarfing and chlorophyll development may be determined by 1, 2 or 3 pairs of factors, and the production of hairs and awns, and the winter or spring habit of growth, by either 1 or 2 pairs of factors. In oats there is good evidence of as many as three pairs of factors affecting grain colour and ligule development, and of two pairs affecting pubescence and side or open type of panicle. This is in sharp contrast with the situation in barley or rye, in which duplicate factors are relatively rare, and single factor differences are common.

Of course, duplicate factors can arise in a diploid either through parallel gene mutation in different chromosomes or through duplication of parts of chromosomes, but the simplest and most plausible explanation of the common occurrence of duplicate factors in tetraploids and triplicate factors in hexaploids is that they were present in different original diploid species and have been brought together in the cultivated cereals by allopolyploidy.

The occurrence of polymeric factors in cereals may have features of economic importance. Åkerman has put to practical use the occurrence of

duplicate factors for black grain colour in oats. The common black oats of Sweden have only a single factor for black. They give 10-20 white grains per kilo through 'loss mutation', and the quality of the grain is thereby much reduced from the seedsman's standpoint. Crosses were made with a black variety of inferior value, but which was known to carry two factors for black. From these crosses a two-factor black variety of high economic value has been produced which gives practically no white grains. Assuming the rate of internal mutation to remain unchanged and one white grain to have appeared in 10,000 in the one-factor varieties, then in the two-factor variety only one white grain should appear in 100,000,000.

Apart from their effect on the rate of production of *visible* mutations, the presence of one, two or three factors for grain colour in wheat and oats probably has little if any economic significance, but in the study of chlorophyll deficiency in oats, Åkerman found that plants with only one factor for normal chlorophyll were a paler shade of green than those with more than one. This case serves to illustrate a possible bad effect of polymeric factors. The chlorophyll mutation was not noted until it had occurred in all three pairs of factors, though it was probably harmful from the time it occurred in the first pair affected. It seems probable that similar harmful mutations may often occur and remain undiscovered in polyploids because other similar or identical factors are present.

This opinion is supported by the recent work of Harrington and Smith (*2*). In the F^2 of a cross between two varieties of *T. dicoccum* (tetraploid) approximately 1/16 of the seedlings were yellow and lacked chlorophyll. Genetic study showed that each of the parents must have carried one recessive gene for inhibition of chlorophyll development. But because they carried also an epistatic normal gene for chlorophyll, the presence of the harmful gene was not apparent. Similarly in a cross between *T. dicoccum* and *T. vulgare* (tetraploid $\times$ hexaploid) Smith and Harrington (*3*) obtained albinos in ratios which suggested that one parent carried two recessive genes for albinism and the other carried one. From their respective tetraploid and hexaploid nature it seems almost certain that it was *T. dicoccum* that carried the one harmful gene, and *T. vulgare* which was able to carry two such genes without showing their effect.

Mutations Attributable to Polyploidy

The speltoid and fatuoid mutations of wheat and oats respectively seem to be fairly clear cases illustrating the effect of polyploidy in producing mutations. The appearance of these forms in cultivated wheat and oats has been shown to be correlated with chromosome aberration. Different genetic types of these mutants, all similar in appearance, may apparently arise through interchange of a pair of chromosomes, or through gain or loss of a chromosome, and the heterozygous mutant form can therefore be obtained with 41, 42 or 43 chromosomes. The 'homozygous' mutant types segregated from these have 40, 42 and 44 chromosomes respectively, and by making the appropriate crosses or through further chromosome aberration they can be obtained with 41 and 43 chromosomes also. The results are explicable if the characters of cultivated wheat and oats involved are deter-

mined by the interaction of rather distinct pairs of factors, situated on different *similar* (but not identical or truly 'homologous') chromosomes which have been brought together by allopolyploidy. The mutant form then arises whenever the balanced interaction is upset.

The variation in the rate of production of mutant forms, especially of speltoids and fatuoids, shown by different varieties of wheat and oats seems possibly to be correlated in part with their age. Some of the oldest European varieties of oats for instance very rarely produce fatuoids, but these occur frequently in most if not all varieties of recent origin. Hybrids between hexaploid species or even varieties of cereals sometimes have irregular chromosome behaviour, and the crossing of varieties may induce aberrations in later generations. This again might be expected if they are allopolyploids, and may be compared with Karpechenko's (4) fertile tetraploids of Cabbage × Radish which breed true when selfed but give aberrant forms when different F_1 plants are crossed.

Fulghum and similar oat varieties produce an exceptional number of mutant forms, and it seems significant that they are commonly held to have originated from crosses of *A. sativa* and some cultivated form of *A. sterilis*. The problem of the rate of mutation in cereals is, however, always complicated by the possibility of natural crossing, and natural crossing occurs more frequently in plants which are cytologically abnormal than in normal ones.

Chromosome Aberrations Hidden by Polyploidy

One feature of the fatuoid and speltoid work bears on the effect of polyploidy in hiding harmful mutations and also on the problem of the origin of dwarfs. Fatuoids or speltoids with 41 chromosomes instead of 42 are almost as vigorous as normal plants, and a 41 chromosome wheat plant has been found which could not be distinguished in appearance from other plants of the variety in which it occurred. The seed production of these plants is however much below normal and any 40-chromosome progeny from them are usually quite dwarf and sterile. Such plants occurring in cultivated wheat and oat varieties must reduce the yielding capacity to some extent. Their occurrence is directly attributable to polyploidy, as in diploid species chromosome aberrations do not occur so frequently and, even if formed, such plants with one less than the diploid chromosome number would commonly be non-viable.

A further effect of polyploidy is also illustrated by 41-chromosome fatuoids. In a population of self-fertilised plants a single factor mutation in the absence of selection is very soon reduced to negligible proportions, since in every generation one quarter of its progeny are normal plants. One strain of 41 chromosome fatuoids has, however, been found to give about 20 plants like itself for every normal it produces. In the absence of selection the proportion of such plants would therefore be reduced by only 1/20 in each generation. Further, the fatuoid mutation seems to occur much more frequently in normal plants descended from fatuoids than in ordinary normals. Owing to differential viability and seed production, however, no general rule for the rate of elimination of chromosome mutants can be formulated.

In support of the view that cultivated wheat and oats are allopolyploids a few results of species hybridisation studies in wheat may be cited. From crosses of *Aegilops ovata* × *T. dicoccoides* and *Ae. ovata* × *T. durum* (each of which has 28 chromosomes) Tschermak and Bleier (*5*) have obtained new fertile forms, which they call *Aegilotricum* spp., with 56 chromosomes.

From an ineffectual pollination of *T. compactum* with *Ae. cylindrica*, Gaines and Aase (*6*) obtained a haploid wheat plant with only 21 chromosomes. These did not mate at all in germ cell formation, as they might have done if *T. compactum* had been an autopolyploid species. Sax and Sax (*7*) found that in a cross of *T. vulgare* × *Ae. cylindrica* seven chromosomes from each species united in germ cell formation. In the cross *T. monococcum* × *T. spelta*, Melburn and Thompson (*8*) found that not more than five chromosome pairs were formed. In hybrids between wheats with 28 and 42 chromosomes, 14 pairs are usually formed. The differentiation between the chromosomes of the 42 chromosome wheats has been assumed by some authors to have occurred since the original duplication. It is, however, difficult to see how differentiation could occur in an autopolyploid which would make the three sets of *T. vulgare* incapable of mating among themselves, but leave one set of them capable of mating with the set from *Ae. cylindrica*. If however *T. vulgare* is an allopolyploid and *Aegilops* either one of its ancesters (as Percival has maintained) or a member of a collateral line, the chromosome behaviour is understandable.

Further presumptive evidence that cultivated wheat and oats are allopolyploid is to be found in the fact that most of their characters are found in whole or in part in species with lower chromosome numbers. This last can be explained by assuming that parallel mutations have occurred in different species, but hybridisation followed by chromosome doubling as the evolutionary mode of these genera affords a simpler and more plausible explaination.

It is perhaps well to stress, however, that no simple, straightforward process is implied. When we proceed to details, most of the definitions break down and criteria of similarity, such as the pairing of chromosomes, may prove to be inapplicable in a strict sense. Leaving aside the possibility of gene mutation, it is now certain from the studies of Belling and others that important physical changes can occur in a set of chromosomes. A piece can apparently be broken off from one end of a chromosome and attached to a member of another pair. If this occurs in a diploid species some of the second generation progeny, while still diploid in their number of whole chromosomes, will be 'polysomic' or 'polyploid' in parts of their chromosomes. The same condition could result from inversion of a chromosome segment followed by crossing-over. Polymeric factors could thus arise without gene mutation in diploids, as in polyploids. The difference is that in the former they would be more or less rare, whereas in the latter they should be of common occurrence.

Similarly, though stress has been laid on the difference between allopolyploids and autopolyploids, and though this distinction is almost certainly significant with regard to their relative importance in evolution, yet in detail the distinction is not exact. For example, the two species which have been

the parent of any allopolyploid, may have been distinct in most of their chromosomes, but have had one or two pairs in common, and chromosome differentiation is in any case only relative. Thus *Primula kewensis,* investigated by Newton and Pellew (*9*), has 9 chromosomes from *P. floribunda* and 9 from *P. verticillata.* These form nine pairs in the sterile diploid hybrid, but in the fertile tetraploid form produced by chromosome doubling in the somatic tissue the 36 chromosomes commonly form 16 pairs and 1 quadrivalent or association of 4 chromosomes. There is clearly an affinity between all the 'homologous' chromosomes of the two species, but judged on the basis of metaphase mating it is evidently weak in most of them, or they would form nine quadrivalents in the tetraploid.

Similarly in cultivated oats and wheat, the 42 chromosomes are evidently fairly well differentiated, since they nearly always form 21 pairs. But occasionally matings take place between more than two chromosomes. So long as chromosome mating takes place only between the identical chromosomes present through chromosome doubling, allopolyploids breed true for their hybrid type. But when mating occurs between the chromosomes of one parent, or between more than two chromosomes, then new 'mutant' types may appear, and these may often simulate gene mutation. Of course without detailed investigation it is usually impossible to differentiate between gene mutations and mutations which have arisen through chromosome aberration, and which are in essence therefore rather the products of segregation than of mutation in its strictest sense. This fact renders invalid many of the generalisations made concerning mutations. Garber (*10*), for example, recently cited dwarfness, fatuoids, speltoids and chlorophyll abnormalities as gene mutations in the small grains. Of these the first three are, in many cases at least, quite clearly produced by aberrations involving whole chromosomes. The latter may be gene mutations, but they may equally well be deficiencies or losses of parts of chromosomes. Only in forms which have been extensively studied, such as Drosophila, and perhaps Maize, is it possible to differentiate with any degree of accuracy between gene mutations and chromosome mutations of the deficiency or duplication type. The colour mutation of oats from black to white grains is one which seems most obviously to be a case of gene mutaton, but this could also arise through either faulty chromosome pairing or deficiency.

Cereal Hybrids

While in general, crosses between varieties or species of the polyploid cereals with the same chromosome number give good mendelian ratios, numerous exceptions have been recorded. The irregular results from crosses of *T. vulgare* and *T. Spelta* may serve as an example. Nilsson-Leissner (*11*) found that the type of glume in this cross segregated commonly in a ratio of 3:1, but sometimes in almost the reverse proportions, and a number of abnormal types also arose. Some personal observations on the cytology of this cross show that chromosome behaviour is irregular, and it may well be that this is one of the causes of the irregular genetic results. Analogous results from crosses of hexaploid oats have been obtained by my colleague Mr. J. Philp, who also finds chromosome irregularities in the F_1 plants.

The 'suppression of characters in crossing' observed by Biffen and others, and the 'shift' of the mean glume length noted by Engledow in crosses between polyploid wheats, are probably due to pairing taking place between the chromosomes of the parental sets, as suggested by Darlington (*12*). The causes giving rise to these phenomena are, on this theory, similar to those giving rise to fatuoids and speltoids, except that in the former case they occur in a hybrid, whereas in the latter they may occur in a pure variety.

Until genetic analysis of the cereals has proceeded to the point where gene mutations can be distinguished with certainty from chromosome aberrations, it is impossible to determine the importance of the former in producing variation. The genetic constitution of the polyploid cereals appears, however, to be so rich in diverse hereditary factors that the economic importance of possible recombinations seems enormously to outweigh the possibilities of gene mutation. This is particularly the case if to recombinations produced in the ordinary way by hybridisation there be added the recombinations produced within the nucleus by chromosome aberration, polyploidy, etc. Such internal recombinations may apparently be brought about by various agencies, especially by X-rays and chilling. In Drosophila X-rays have been shown to produce both gene mutations and chromosome aberrations. The mutant forms produced by the latter, where distinguishable, might reasonably be classified as products of 'internal hybridisation', since they arise only through recombinations of existing genetic factors.

If many of the valuable features of cultivated wheat and oats are due to their having arisen through hybridisation followed by chromosome doubling, as seems evident, then it would seem to be worth while to attempt by artificial means, such as cold treatment and the cutting-back of plants, to produce tetraploid forms of hybrid barleys or rye.

Polyploids and Pure Lines

Another feature of polyploidy of interest to the cerealist is its bearing on the pure line theory. Since the establishment of this theory by Johannsen and its general acceptance by geneticists it has been adopted by cerealists as applicable to all the self-fertilized grains. In this the polyploid nature of wheat and oats has not been sufficiently considered. Absolute true breeding in my opinion cannot be expected and does not occur in polyploids. Some of the oldest established varieties of wheat and oats do remain relatively constant, but other varieties are continuously throwing mutant or off types. In part this may be due to occasional natural crossing, but in other cases it is undoubtedly due to irregular chromosome behaviour. Sapehin (*13*) has found gross chromosome irregularities in a number of 'pure lines' of wheat. Percival has continuously attacked the pure line theory as applied to wheat, and cereal breeders of long experience have acknowledged that while they have produced varieties which for all practical purposes are pure, yet they have not obtained *absolutely* pure lines in any strains of polyploid cereals produced by hybridisation. The Vilmorin wheat which showed no variation in type after 50 years of cultivation is often cited as evidence for the pure line theory. Actually it proves only that continuous selection can keep a strain true to type, since selection of typical plants or roguing of off-types

must have occurred in most if not all of the 50 generations. In order to maintain the yielding capacity of cereal varieties at their maximum, it is almost certainly necessary that continuous careful selection and re-testing should be carried out. The necessity of correlating intensive cytological study with genetic analysis in the case of polyploid cereals, if not in all cases, is also obvious.

Summary

Wheat, oats, barley and rye all have the basic chromosome number seven. Polyploidy, the replication of this basic number, has played an important part in the evolution of wheat and oats.

The kind of polyploidy involved is, in the author's opinion, allopolyploidy, i.e. chromosome doubling after hybridization. Allopolyploidy serves to perpetuate the results of hybridisation in relatively true-breeding forms.

The common occurrence of polymeric or duplicate factors in wheat and oats is attributed to polyploidy. From the agricultural standpoint they may have both good and harmful effects.

The relatively frequent occurrence of chromosome aberrations in wheat and oats is also attributable to polyploidy. These aberrations may simulate gene mutation.

The author doubts the strict applicability of the pure line theory to polyploids.

LITERATURE CITED

1. Åkerman, Å. Untersuchungen über eine in direktem Sonnenlichte nicht lebensfähige Sippe von *Avena sativa*. Hereditas *3*: 147-177. 1922.
2. Harrington, J. B., and W. K. Smith. Yellow seedlings in wheat. Scientific Agr. *9*: 147-153. 1928.
3. Smith, W. K., and J. B. Harrington. Wheat albinos. Jour. Heredity 20: 19-22, 1929.
4. Karpetchenko, G. D. Polyploid hybrids of *Raphanus sativus* × *Brassica oleracea*. Zeit. Ind. Abst. u. Verer. *48*: 1-85. 1928.
5. Tschermak, E. and H. Bleier. Uber fructbare Aegilops—Weizenbastarde. Bericht. Deut. Bot. Ges. *44*: 110—132. 1926.
6. Gaines, E. F. and Hannah C. Aase. A haploid wheat plant. Am. Jour. Bot. *13*: 373-385. 1926.
7. Sax, K. and Sax, H. J. Chromosome behavior in a genus cross. Genetics *9*: 454-464. 1924.
8. Melburn, M. C. and W. P. Thompson. The cytology of a tetraploid wheat hybrid. Am. Jour. Bot. *14*: 327-333. 1927.
9. Newton, W. C. F. and Caroline Pellew. *Primula kewensis* and its derivatives. Jour. Genetics *20*: 405-467. 1929.
10. Garber, R. J. The nature and significance of mutations in present day breeding methods. Scientific Agr. *9*: 133-143. 1928.
11. Nilsson-Leissner, G. Beiträge zur Genetik von *Triticum Spelta* und *T. vulgare*. Hereditas *7*: 1- . 1926.
12. Darlington, C. D. The behavior of polyploids. Nature *119*: 390-391. 1927.
13. Sapehin, A. A. Hylogenetic investigations of the vulgare group in Triticum. Bull. App. Bot. *19*: 127-165. 1928.

ABNORMAL SEED DEVELOPMENT IN SWEET CLOVER SPECIES CROSSES—A NEW TECHNIQUE FOR EMASCULATING SWEET CLOVER FLOWERS*.

L. E. Kirk †
University of Saskatchewan, Saskatoon, Sask.

[Received for publication August 5, 1929.]

Sweet clover occupies a place of growing interest and importance as a cultivated crop. A large number of distinct and interesting forms have become available through introduction, inbreeding and selection. In order to make the most of these from a plant breeding standpoint, and in order to make possible a genetic study of contrasting characters, it was necessary that a satisfactory means be found for emasculating the flowers so that crosses could be made without excessive effort and with a reasonable degree of success.

It is practically impossible to remove the stamens of sweet clover flowers before they are mature for the reason that they must be manipulated in the bud stage and the resulting mutilation almost always results in the destruction of the flower. The "jet of water" method (*4*), for several reasons, has proven somewhat unsatisfactory with this plant. After making numerous attempts to devise a suitable technique, success has finally been obtained by an application of the vacuum principle, whereby the stamens and adhering pollen are removed by suction. This paper contains a description of the "suction" method together with an account of the results secured. It will be advisable first, however, to discuss the result of crossing white-blossom and yellow-blossom sweet clover, since the abnormal seed development which was discovered as a result of crossing the two species proved to be not only of much interet in itself, but also a valuable check on the efficiency of the method used in emasculating the flowers.

In a recent paper, the writer (*3*) expressed the view, based on experience and controlled experiments, that natural crosses between white-flowered and yellow-flowered sweet clover were of very rare occurrence. In the experiments referred to, only one hybrid plant was found in a population of 11,400 plants, which were grown from seed produced under conditions which provided the optimum chances for cross-pollination. Our experiments in the technique of crossing has thrown some light on this matter and explains in part why natural hybrids between white and yellow sweet clover are not more frequent.

When white-blossom sweet clover is pollinated with pollen from a yellow-flowered plant, or when the reciprocal cross is made, a pod and seed are produced, but both are much smaller than the normal pod and seed. In addition to being smaller, the seeds do not develop nor mature properly. They are green in color, undersized, and more or less shrunken, but in other respects appear to be completely formed. So far, it has not been possible to get them to germinate. It is assumed that the abnormal seeds are the

*Contribution from the Department of Field Husbandry.
†Professor of Field Husbandry.

Figure 1.

Figure 2.

Figure 1. Left: Raceme of white-blossom sweet clover showing size of pods at maturity: the flowers had been emasculated and crossed with yellow-blossom sweet clover. Right: Natural pod development on an adjacent raceme of the same plant. (Natural size).

Figure 2. Two adjacent racemes of yellow-blossom sweet clover from the same plant, showing pod development. Both were emasculated by the "suction" method at the same time. Left: Flowers crossed with white-blossom sweet clover: note very small pods each of which contains a shrunken seed similar to those shown in Fig. 3, the arrows point to two pods of normal size which are probably selfs. Right: flowers artificially pollinated with pollen from the same plant: note normal pod development. (Natural size).

product of cross-fertilization, although the possibility of parthenocarpy is not excluded.* That they are not the result of manipulating the flowers is clear because only normal pods and seeds were produced when the emasculated flowers were pollinated with pollen from the same plant. This incomplete development and resulting impotency of the seeds apparently accounts for the fact that natural crossing between white-blossom and yellow blossom sweet clover rarely results in hybrid plants.

Table 1 gives the number of seeds of white-blossom sweet clover resulting from flowers which were emasculated by the "suction" method and fertilized with pollen from yellow-blossom plants compared with the number resulting from flowers which were emasculated but not pollinated. Racemes were manipulated in pairs, always on the same plant, at the same stage of development, and in the same day and hour. Racemes on which the flowers were emasculated only and the corresponding ones which received pollen from the other species have been placed opposite in the table for comparison. Table 2 gives the results in the same form for the reciprocal cross.

*That the abnormal seeds may be due to parthenocarpic development was suggested by Dr. R. A. Brink, Associate Professor of Genetics, University of Wisconsin.

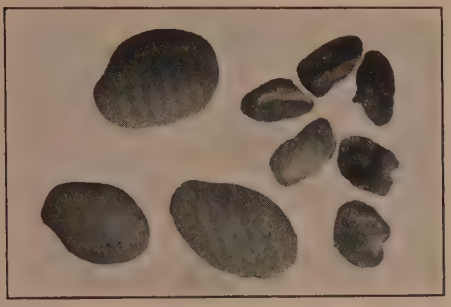


Figure 3. Normal and shrunken abnormal seed, the latter resulting from crossing white-blossom and yellow-blossom sweet clover and the reciprocal cross. (Magnified about 8 times).

TABLE I. *Number of seeds of white-blossom sweet clover resulting from flowers which were emasculated by the "suction" method and pollinated with pollen from yellow-blossom plants, compared with the number of seeds resulting from flowers which were emasculated but not pollinated.*

Date when flowers were manipulated	Cross-pollinated			Emasculated only.	
	Number of flowers	Number of seeds (Abnormal)	Number of seeds (Normal)	Number of flowers	Number of seeds (Normal)
1928					
July	156	136	10	163	27
1929					
June 27				64	9
" 27	13	11	0		
" 27	22	10	0		
" 28	30	5	1	30	1
July 10	34	18	0	28	7
" 10	22	12	0		
" 11	28	9	2	22	1
" 11	24	12	3	25	2
" 12	20	14	2	20	3
" 12	20	8	0	20	3
" 12	20	7	1	20	2
" 12	20	12	2	20	1
" 12	20	12	0	22	4
" 13	38	28	4	20	8
" 13	20	18	0	27	0
" 13				20	2
" 16	20	9	3	20	0
" 16	20	11	1		
" 16	20	7	3	20	5
" 16	20	16	2		
" 17	20	14	0	20	1
" 17	20	13	2	20	0
" 18				20	3
" 18				20	0
Total	607	382	36	621	79
Per Cent Seed Setting		62.9	5.9		12.7

It is evident from the data presented that the method used in emasculating sweet clover flowers was about 87 per cent efficient. On racemes which were emasculated and cross-pollinated, 68.6 per cent of the flowers set seed, 61.6 per cent being abnormal and 7.2 per cent normal. The latter were considered to be the product of self-fertilization as a result of failure to

TABLE 2. *Number of seeds of yellow-blossom sweet clover resulting from flowers which were emasculated by the "suction" method and pollinated with pollen from white-blossom plants, compared with the number of seeds resulting from flowers which were emasculated but not pollinated.*

Date when flowers were manipulated	Cross-pollinated			Emasculated only	
	Number of flowers	Number of seeds (Abnormal)	Number of seeds (Normal)	Number of flowers	Number of seeds (Normal)
1929					
June 27				21	3
" 27	22	16	2	20	3
" 28				26	4
" 28	23	19	1	20	4
July 8	22	15	2		
" 10	30	16	0	26	3
" 11	30	16	2	28	1
" 11	22	16	2		
" 12	20	17	0		
" 12	20	9	4	20	2
" 12	20	10	3	20	1
" 16	30	13	4	30	1
" 17	23	13	3	23	2
" 17	26	20	5	24	1
" 18	25	12	0	36	10
" 18	20	9	0	20	5
Total	333	201	28	314	40
Per Cent Seed Setting		60.4	8.4		12.7

remove all of the pollen. It was to be expected that a few selfed seed would be produced since, on racemes which were emasculated only, 12.7 per cent of the flowers set seed. While the number of seeds obtained from cross-pollinated flowers was only 68 per cent, this is not very different from the per cent of seed setting when emasculated flowers under the same conditions were fertilized with pollen of the same plant.

METHOD OF EMASCULATING THE FLOWERS

The following is a detailed account of the method which is used for emasculating and pollinating sweet clover flowers. Roots are taken up early in the spring and transplanted into a greenhouse which has been screened to exclude bees and other insects. It is convenient to have the plants growing in a large box about two feet deep constructed on the floor of the greenhouse, as this gives the maximum space above for plant growth. A water tap to provide the necessary suction pressure should be located in the vicinity. A filter pump, ⅜ inch pressure hose, vacuum flask and glass nozzle, completes the equipment. The vacuum flask is inserted in the hose line. A short piece of glass tubing to fit the hose, and drawn out to a bore of slightly less than 1 mm. in diameter, makes the nozzle. The fine point of the latter must be carefully smoothed in a flame in order that it may not injure the delicate parts of the flower.

The amount of suction maintained in the hose is of considerable importance. Water pressure at taps is usually quite variable, especially in mid-summer when sprinklers are being used on the lawns. Best results were secured in these experiments by working early in the morning when the

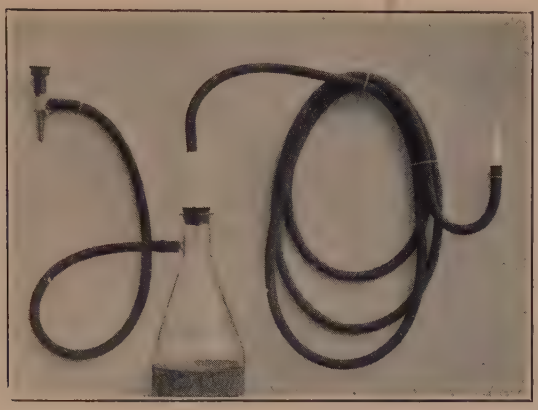


Figure 4. Apparatus used in emasculating sweet clover flowers by the "suction" method. See text for description.

pressure was least variable. It is possible that lowered pressure was responsible for the poor results obtained in the few instances recorded in the tables. If the pressure is above 30 pounds, a Cenco-Harrington aspirating pump can be used with advantage because of its greater efficiency than the ordinary pump. Under these conditions, good results may be expected.

Running water, of course, is not the only means for creating a partial vacuum. An electrically driven suction pump or other mechanical means could easily be devised for this work and made to maintain a uniform suction pressure. Portable devices also, for use in the field, could be easily constructed.

The success of the "suction" method of emasculating depends upon the thoroughness with which all of the stamens and adhering pollen are removed. A raceme is chosen on which some of the flowers at the tip have not yet opened. These are removed, together with many of the older flowers at the base of the raceme, leaving only about 20 or less of the recently expanded blossoms. The petals of the flowers to be manipulated are then pulled off with suitable tweezers. This invariably ruptures the stamens and scatters the pollen. Water is turned on at the tap and the nozzle applied to the flowers for the purpose of removing both stamens and adhering pollen.

The nozzle should approach the stamens from the base or side of the staminal tube, and if the suction is sufficiently strong, the stamens will be quickly and easily taken in. If the flower is approached from the top, the pistil and staminal tube will be drawn in with force. This results in coating the inside of the nozzle with sticky fluid to which the pollen grains adhere. Under these circumstances, it is probable that there is a tendency for the pollen grains to become attached to the stigma so strongly that they cannot always be removed. It is an advantage if the inside of the nozzle is kept dry.

When the operator is at work, he should wear a low power binocular magnifier on the head, leaving his hands free. An instrument of this kind is regarded as essential for best results. Indeed, it is doubtful if good work can be done without it, as it is difficult to observe with the naked eye that all the stamens have been removed. When the magnifier is worn, the pollen

grains also are plainly visible. While one cannot hope to see that every pollen grain has disappeared, it is possible to tell with a reasonable degree of certainty when this has been accomplished. Having first removed the stamens, the operator proceeds to pass the end of the nozzle over the surface of each style and stigma, and also over the sepals and axis of the raceme.

Having made reasonably sure that the stigmas are free from pollen, crosses are made by pollinating the emasculated flowers immediately. Removing the petals and leaving the pistil exposed does not appear to interfere with seed setting. Pollinating may be done most effectively by applying the pollen to the stigmas with the end of the thumb-nail.

Discussion

The occurrence of shrivelled seed in inter-species crosses has frequently been observed. In crosses between 14 and 21 chromosome wheats, Thompson (*5*) has shown that shrivelled seed is obtained when the 14 chromosome wheat is the female parent and that the shrivelling is due to deficient endosperm development, resulting from an unbalanced chromosome condition in double fertilization. The abnormal seeds of sweet clover cannot be associated with endosperm development since, in legume seed, the place and function of the latter is taken by the two cotyledons which occupy almost the entire space within the seed coat. Nor is there any reason to suspect an unbalanced chromosome condition due to different numbers in the two species. Castetter (*1*) and Elders (*2*) both reported 16 chromosomes as the diploid number of *Melilotus alba* and Elders found *Melilotus officinalis* also to contain sixteen. All that can be said with our present information is that the abnormal seed development resulting from cross-pollination in the two species seems to indicate either that we are dealing with a rather wide cross or a high degree of incompatability.

Although the seeds obtained proved to be abnormal and non-viable, the fact remains that, in another study previously referred to, the writer obtained a natural hybrid between the yellow-blossom and white-blossom species of sweet clover. It must be assumed, therefore, either that it is occasionally possible for an abnormal seed to germinate and produce a plant or that normal viable hybrid seeds may sometimes occur. There is a possibility that some of the few normal seeds which developed on racemes from flowers which were emasculated and cross-pollinated may produce hybrid plants. This possibility will be tested in due course by growing the plants to maturity.

Although the "suction" method of emasculation cannot be relied upon to give perfect control in the crossing of sweet clover, it is sufficiently efficient and convenient to make crossing a practicable procedure. It is quite possible that the degree of efficiency (87 per cent) which was secured by the method in these first trials, may be increased to almost 100 per cent by improvements in the technique.

The use of the suction method of emasculating flowers, may be found to have a rather wide application in making crosses between other species of plants. We have used it quite extensively on alfalfa, with excellent results. In fact it is even better adapted to alfalfa than to sweet clover.

By cutting away the upper part of the standard of an alfalfa flower and tripping it, the stamens are exposed and may be easily removed by suction. As a rule, tripping of the flowers in this manner does not rupture the stamens, so that emasculation may be easily effected. With alfalfa, however, the limiting factor in making crosses is not the difficulty of emasculating the flowers, but rather the inability of the plants to set seed except under exacting conditions.

Summary

1. When white-blossom sweet clover is crossed with yellow-blossom sweet clover, or vice versa, small shrunken non-viable seeds are produced. Of 940 flowers emasculated and cross-pollinated, 647, or 68.8 per cent, set seed, of which 583, or 61.6 per cent, were abnormal. About the same proportion of emasculated flowers produced normal seed when pollinated with pollen from the same plant.

2. Abnormal seed development is assumed to account for the rarity of natural hybrids between the white-flowered and yellow-flowered species of sweet clover.

3. About 7 per cent of the emasculated and cross-pollinated flowers produced normal seeds. These are believed to be the result of self-fertilization but the possibility is recognized that some of them may be hybrid seed.

4. A new technique for emasculating the flowers of sweet clover by suction is described in detail. Of 935 flowers which were emasculated but not pollinated, 119 or 12.7 per cent, set seed. In these experiments, therefore, the "suction" method may be said to be about 87 per cent efficient.

LITERATURE CITED

1. Castetter, E. F. Studies on the cytology of *Melilotus alba*. (Abstract) Iowa Acad. Sci. *30*: 231. 1923 (1924).
2. Elders, A. T. Some pollination and cytological studies of sweet clover. Sci. Agr. *6*: 360-365. 1926.
3. Kirk, L. E. Natural crossing between white-flowered and yellow-flowered sweet clover. Sci. Agr. *9*: 313-315, 1929.
4. Oliver, G. W. New methods of plant breeding. U. S. Dept. Agric. Bur. Plant Indust. Bull. 167, 1910.
5. Thompson, W. P. Chromosome numbers in functioning germ cells of species-hybrids in wheat. Genetics *13*: 456-469. 1928.

IS ALL MILK EQUALLY SUITABLE AS A MEDIUM FOR THE PREPARATION OF STARTERS?

C. D. Kelly
The University of British Columbia, Vancouver, B.C.

[Received for publication July 10, 1929]

The use of high grade milk for the preparation of starters is a well established custom. While engaged in the building up and preparation of starters in a large dairy I have been employing certified milk as the necessary medium for the procedure. Taking for granted that this milk was the best procurable, it was with no little surprise that I found myself beset with difficulties. Not infrequently, after the first or second transfer, *new* starters have evinced a flat, almost yeasty, flavour not unlike fermenting bread dough. Usually, this flavour has disappeared after successive inoculations and a clean acid flavour with the aroma peculiar to a good starter has developed; yet, in several starters prepared early in 1928, the flat yeasty flavour persisted even after many transfers. Six different "starter cultures" from one laboratory were secured in an attempt to get one from which could be prepared a starter with a clean acid flavour. As long as the same milk was being used as the culture medium, the resulting starters were quite unsatisfactory.

The possibility of the starter having become contaminated from the milk medium was not to be overlooked. Consequently the most scrupulous care was taken in all procedures and, particularly, the temperature at which the milk was heated was carefully controlled. As these precautions were of no avail, it was finally decided to use milk from another herd as the medium in which to grow the starter. With much surprise it was noted that all the starters developed a good clean acid flavour after the second transfer in this milk and retained it through succeeding transfers in the same medium. From past experience it did not seem possible that the milk should be the cause of such a decided change in flavour, but on growing the starter culture again in the certified milk, the flat yeasty flavour was apparent after a few hours. Each time when transferred to the milk of the other herd the starters took on a clean acid flavour, only to develop the flat yeasty flavour again when cultured in the certified milk.

The starter cultures themselves were considered as being a possible contributing factor to the flat yeasty flavour and therefore starters were forthwith prepared in the certified milk, using a starter culture received from another laboratory. The flavour and aroma of the resulting starter were found to be satisfactory in every way.

Baker and Hammar (*1*), investigating the effect of milk from different sources on the flavour, aroma, and acidity of starters, found that good starters could not be prepared when the milk from certain cows was employed as the medium. This appeared to be due largely, however, to flavour defects inherent in the milk, as salty and rancid flavours; whereas with the certified milk, in the present investigation, the flavour of the original milk

was excellent and it was only with starter cultures from one laboratory that the trouble was experienced.

The difference in flavour of the starter, when grown in the certified milk and in the milk from the other herd, was so decided that it was considered desirable to study the problem further and, for ease and clarity in presenting the data, the milk from the two sources are called here, milk C and milk O respectively.

Milk C; Certified milk, fulfilling the bacterial requirements for certification—10,000 bacterial colonies per cubic centimeter in summer and 5,000 in winter (*2*). This milk was from a mixed herd of Jerseys and Guernseys and had an average butter-fat content of 4.3 per cent.

Milk O; An unpasteurized milk bottled on the farm for delivery in the city, and having a bacterial content somewhat higher than the certified milk. This milk was from a pure bred Holstein herd, and had an average butter-fat content 3.4 per cent.

The following test of the starter, as given below, was made in both milk C and milk O under carefully controlled conditions. A commercial starter culture, fresh from the laboratory, was used to inoculate flasks of milk C and milk O respectively. The milk had been held in flowing steam for an hour—the manner of heating usually employed in the dairy when preparing starters for commercial use. The flasks contained 100 cubic centimeters of milk C and milk O respectively, and 3 cubic centimeter portions of the starter were used for inoculation. Each determination was done in duplicate. In all the flasks the milk clotted with a clean solid clot in about 18 hours. When examined for flavour, the starters prepared by using milk O as the medium had the clean flavour and aroma typical of a good starter, while those made by employing milk C as the medium had the flat yeasty flavour characteristic of the starters grown in this milk.

The manner in which the flat yeasty flavour of a starter prepared by using milk C appeared to persist, suggested that work be done on the bacterial content of the starter. Accordingly the milk C starter was plated, using "Bacilac Agar"—a milk agar—as the medium. Subcultures were made from several colonies and these cultures were retained in chalk milk, after the method of Barthel (*3*), pending further study.

Action in Milk C and Milk O of Organisms Isolated from Milk C Starter

After having been held in stock for a short time, two cultures KL_2 and KL_{52} were grown, independent of one another, in milk C and milk O respectively, the object being to see if, in the respective milk supplies, pure cultures produced a flavour comparable with the flavours found when building up a starter from a mixed commercial culture. Strains KL_2 and KL_{52} were each found to produce the flat yeasty flavour in milk C and in milk O. Transfers of these cultures in milk C and milk O respectively were made from day to day and incubated at 21°C, as is the common practice in carrying on the usual starter. The undesirable flat yeasty flavour per-

sisted until the eighth transfer. Then a clean acid flavour developed in the milk O cultures, whereas in the milk C cultures the defect still persisted. The flavour of milk O, inoculated with Cultures KL_2 and KL_{52} respectively, continued to be clean and satisfactory and the cultures were used with success in the preparation of "Commercial Buttermilk".

Cultural Study of Strains KL_2 and KL_{52}

Media Employed.

Litmus milk: skim milk, to which sufficient azo-litmin solution was added to give the desired colour, was sterilized at fifteen pounds pressure for twenty minutes.

Chalk milk: skim milk, to which had been added precipitated calcium carbonate at the rate of 3.0 per cent., was sterilized at 15 pounds pressure for twenty minutes (*3*).

Nutrient-agar: Difco (*4*).

Beef-extract-gelatin: Manual of Methods (*5*).

Glucose-gelatin; Beef-extract-gelatin to which glucose was added at the rate of 1.0 per cent.

Broth for Sugar Fermentations: The casein-digest-broth of Orla-Jensen (*6*) was used, the respective sugars being added at the rate of 2 per cent; the medium was tubed and sterilized at thirteen pounds pressure for twenty-five minutes.

Cultural Characteristics.

Cultures KL_2 and KL_{52} are Gram positive organisms, round to oval, growing readily at 23°C. They form short chains in milk, the cells being enclosed in capsules in fresh milk cultures. They do not liquefy gelatin, and nitrates are not reduced to nitrites. A clean acid clot is produced in litmus milk in twenty-four hours and the litmus is bleached from the bottom, leaving an unbleached portion at the top. Growth on nutrient-agar and nutrient-gelatin is poor.

The ability of the strains to ferment eighteen carbohydrates to acid have been determined quantitatively, following Orla-Jensen (*6*). The results given in table 1 are expressed as grams lactic acid per mille.

Table 1

No.	Isolated from	Nitrogen Source	Volatile Acid Figure	Glycerine	Xylose	Arabinose	Rhamnose	Sorbite	Mannite	Laevulose	Glucose	Mannose	Galactose	Saccharose	Maltose	Lactose	Raffinose	Inulin	Dextrin	Starch	Salicin	Milk: Time of Curdling Days	Milk: Amount of Acid
KL_2	Starter.	Casein-digest	3.4	0.2	0	1.0	0.1	0.2	0.7	5.6	6.1	5.7	4.5	0.8	0.7	5.4	0.5	0	0	0.2	2.8	1	5.7
KL_{52}	Starter.		12.2	0.7	0.5	1.1	0.6	0.8	0.8	5.7	5.9	5.5	3.6	1.2	1.5	5.4	1.0	0.8	0.7	0.9	3.3	1	6.4

Sugars are titrated against N/4 NaOH with phenolphthalein as indicator and the results are recorded as grams lactic acid per mille.

From a study of the data presented in table 1 it will be noted that Cultures KL_2 and KL_{52} do not ferment dextrin, that maltose and saccharose are attacked but slightly, and that no acid is developed in the first five carbohydrates of the table; whereas large amounts of acid are produced in the hexoses, and in lactose and salicin. These two strains appear to be quite closely allied to *Streptococcus cremoris* Orla-Jensen (*6*) from the rapid clotting of milk, failure to produce acid in dextrin and the five carbohydrates mentioned above, weak acid production in maltose and saccharose, together with the formation of chains and capsules when grown in milk. Due to the presence, however, of the well defined flat yeasty flavour produced in milk, and because of the absence of information on the rotary power of the lactic acid produced, and of the action of the strains on the protein of milk, it does not seem to be advisable, at this time, to classify Cultures KL_2 and KL_{52} as *Streptococcus cremoris* (*6*). It is suggested, therefore considering the close agreement of these two strains with *Streptococcus cremoris* in certain specific characteristics, that each strain may be tentatively considered as being a variant of *Streptococcus cremoris* Orla-Jensen (*6*).

Summary

A number of "Commercial Starter Cultures" developed a flat yeasty flavour when grown in milk from a certain herd—Milk C—but produced a typical clean acid starter flavour when grown in milk from another herd—Milk O.

Two cultures—KL_2 and KL_{52}—, isolated from Milk C starter, produced the same flat yeasty flavour when grown in milk C but produced a clean acid starter flavour after the first few transfers when grown in milk O.

The strains which appear to be identical are to be considered tentatively as variants of *Streptococcus cremoris* Orla-Jensen (*6*).

Special Note

After this paper was ready for publication it was brought to my attention that Søncke Knudsen (*7*), while working on starters, in Copenhagen, found he could not make good starters, when using certain high grade milk, either from "Commercial Starters" or those made up from laboratory cultures. Milk from other sources gave good results under the same conditions and with the same starters. At another time (*8*) in the Agricultural College, Copenhagen, while comparing a commercial Jersey milk with milk from a healthy cow in the school herd for suitability as bacterial media, Knudsen and Sørensen found that certain lactic acid bacteria did not grow as readily, nor produce as much lactic acid, when grown in the milk from the cow in the college herd as when grown in the commercial Jersey milk. The addition of very small amounts of autolyzed yeast, spinach infusion or hydrolyzed milk, made the milk, which had given such poor results before, equal to the Jersey milk as a medium for certain bacteria.

In a later publication by the same authors (*9*) certain strains of *Streptococcus cremoris,* isolated from starters, which grew very poorly in aseptic milk, even when it was sterilized so as to eliminate the possibility of bacter-

icidal action, are described. Other strains of the same genus were found to grow very well in the same medium. When these less active growing strains were cultured in aseptic milk, to which were made minimal additions of autolyzed yeast, hydrolyzed milk and milk digested by yeast, growth similar to that of the normal strains was obtained. Not only did these additions to the milk change the action of the organisms on the milk but it changed the microscopic appearance of the cells of the same organisms.* They suggest that milk from every normal cow, when drawn aseptically and immediately sterilized, is a poor medium for some strains of lactic acid bacteria. They add that in the usual market milk there may be small amounts of foreign substances or more commonly, small quantities of the products of protein splitting bacteria.

This very distinct contribution of Knudsen and Sørensen throws much light on the problem with which my paper concerns itself.

ACKNOWLEDGEMENTS

It has been my privilege, in preparing this paper, to have had the advice and kind assistance of Professor Wilfrid Sadler, to whom also I am much indebted for help with the Danish references. To the Fraser Valley Milk Producers' Association and to the University of British Columbia respectively, I wish to express my appreciation for laboratory facilities provided.

LITERATURE CITED

1. BAKER, M. P. and HAMMAR, B. W. Influence of the milk on the starter made from it. Res. Bull. 92, Iowa Agr. Expt. Sta., Ames. 1926.
2. KELLEY, ERNEST. Medical milk commissons and certified milk. U. S. Dept. Agri. Bull. 1. Washington, D.C., 1913.
3. BARTHEL SHR. Mjolksyrebakteriernas livslängd Meddelande No. 267 fran Centralanstalten för försöksväsendet på jordbruksområdet. (Summary in English). Stockholm. 1924.
4. Digestive Ferments Company, Detroit.
5. Soc. Amer. Bact. Committee. Manual of Methods, Geneva, N.Y. 1923.
6. ORLA-JENSEN, S. The lactic acid bacteria (in English). D. Kgl. Danske Vidensk, Selsk. Skrifter, Naturv. og Mathematisk Afd., 8, Raekke, V. 2, Høst and Søn, København, 1919.
7. KNUDSEN, SONCKE. Undersøgelser over Syrevackkere. Maelkeritidende, Nr. 14. København, 1926.
8. ———— and SORENSEN, A. Uber Milch als Nahrboden für gewisse Milchsaurbakterien. (Milk as nutrient medium for lactic acid bacteria). Centralbl. Bakt. (etc.) 2 Abt. Orig. 71 (15/24): 500-507. 1 pl. 1927.
9. ———— Bitrag Til Syrevaekkerness Bakteriology. (Contributions to the bacteriology of starters.) Yearbook of Royal Veterinary and Agricultural College, Copenhagen. 1929.

*Knudsen and Sorensen.

A STATISTICAL STUDY OF THE RELIABILITY OF THE EXPERIMENTAL MILLING TEST*

W. F. Geddes and H. E. West
Department of Agricultural Chemistry, University of Manitoba, Winnipeg, Man.

[Received for publication August 31, 1929]

Considerable difference of opinion exists among cereal chemists as to the reliability of the experimental milling tests, since there are several variables which influence the results. The chief variables influencing flour yields are:

1. The inherent characteristics of the wheat samples.
2. The moisture content of the samples before tempering.
3. The humidity and temperature of the mill room.
4. Variations in milling technique.

Obviously, if the last three factors can be controlled, variations in flour yield will be due to the nature of the sample, and the experimental mill results will then be a reliable index of the relative milling value of different wheats.

Although several laboratories control the humidity of the mill room, yet, as far as the authors are aware, very few pay any cognizance to the moisture content of the untempered wheat. The usual practice consists in weighing out 2000 grams of the cleaned and scoured wheat, irrespective of its moisture content, tempering to a definite moisture content and, after the milling is completed, calculating the yield of flour on the basis of 2000 grams, less an arbitrary weight allowed for unavoidable loss. The moisture added in tempering does not enter into the calculations, it being assumed that this is lost by evaporation during the milling process.

This practice has two obvious objections. First, the quantity of dry matter milled varies from sample to sample, depending on the moisture content, and secondly, variable quantities of water are added during the tempering process (which usually consists of two periods), the major portion of water being added from 12 to 24 hours before milling, with a final addition two to four hours before milling. Bailey (*1*) states that his observations "lead to the conclusion that it requires about 72 hours for equilibrium to be reached in this process of distributing the added water throughout the berry." On this basis, the moisture content of the endosperm of different wheat samples, although tempered to the same moisture content, will vary with the original moisture of the wheat, because sufficient time has not elapsed to provide for equilibrium in moisture distribution. This difference in the moisture content of the endosperm has a marked effect on its milling qualities—a dry endosperm being very readily pulverizable—with the result that an excessive amount of break flour is obtained. Furthermore, the outer portion of the endosperm would doubtless be carrying excessive moisture, and hence exhibit a tendency to flake, which would lower the percentage extraction.

*Published as Paper No. 5 of the Associate Committee on Grain Research, National Research Council of Canada.

With regard to humidity, Shollenberger (*2*) has shown that the total yield of mill products depends on the humidity of the mill room, and also on the moisture content of the untempered wheat. With wheats having an original moisture content of 12.0 to 12.9 per cent, 100 per cent returns were obtained when the relative humidity lay between 60 and 69 per cent, while with wheats having original moistures between 11.0 and 11.9 per cent, 100 per cent returns were obtained with relative humidities of 40 to 49 per cent. It is important to secure a uniform total return in experimental milling, because of the method usually used in calculating the yield of flour. In many laboratories, this is obtained indirectly by subtracting the combined weight of bran and shorts from the weight of the wheat sample, less about 2 per cent for unavoidable loss. Any variation in the weight of by-products, due to differences in moisture content, will thus influence the calculated yield of flour. Furthermore, if the total flour is obtained by direct weighing, the yield will be influenced by its moisture content, which depends on the relative humidity of the mill room and the original moisture content of the wheat. Thus if a uniform total return is not obtained, the variation in yields from different wheat samples will be partially due to variations in relative humidity and the original moisture content of the wheats.

With regard to variations in milling technique several factors enter, such as the setting of the break and reduction rolls, and the time allowed for the separation of the mill stocks by sifting. While it may be necessary to vary the set of the break rolls, depending on the size of the wheat berry, yet, when all wheat samples are conditioned to the same moisture content before tempering, very little variation is necessary in the setting of the reduction rolls for different samples. The extent of variation due to milling is to a large degree dependent on the skill of the miller, but by reducing the number of variables in the milling process, the personal equation is reduced to a minimum.

From a consideration of the above variables, the authors were led to the conclusion that comparable results could be obtained only if some measure of control of these variables was exercised, and the work reported below was undertaken with a view to ascertaining how closely flour yields from samples of the same wheat could be replicated when such control was attempted.

Method of Procedure

50 samples, each containing 1740 grams dry matter, drawn from a well mixed lot of western Canadian red spring wheat grading No. 1 Northern, were placed in air-tight containers and conditioned to a moisture content of 13 per cent, by adding the required amount of moisture and allowing to stand for seven days before milling. One hour and a half before milling, each sample was tempered to 15 per cent moisture. Thus, at the time of milling, all the samples weighed 2000 grams on a 13 per cent moisture basis, plus 47 grams of water added at tempering.

The samples were milled on an Allis Chalmers two-stand mill, to which was attached an indicating device to facilitate setting the break rolls to any definite position.

There was also inserted immediately beneath the break and reduction rolls, a tin hopper to eliminate, as far as possible, the lodging of stocks on the wooden ledges, and facilitate the sliding of the stocks into the receiving boxes, which were also tin-lined.

In the milling of the samples, the Minnesota flow sheet, Appendix A, was followed, which called for five breaks and six reductions, with subsequent reductions of the tailings from the sixth until 75 per cent of the total flour was obtained as patent. This was calculated by direct weighing of the total flour after the completion of milling.

The break rolls were mechanically set the same for each break of all the samples, and the reduction rolls set by sound. The separations were made on a gyrating plan sifter and, although the amount of shaking was not timed, it was practically the same for all samples. An attempt was made to keep the humidity of the mill-room at approximately 70 per cent during the milling. Samples of the various mill products were preserved in air-tight containers for moisture determinations by the official vacuum oven method.

The milling data expressed as percentage of 2000 grams (conditioned wheat basis) are given in table 1, while the moisture determinations on the various mill products are reported in table 2, together with the average humidity and temperature of the mill-room. (The figures tabulated for humidity and temperature are the average of three readings taken at regular intervals during the milling of the samples.)

It will be noted by a perusal of table 2, that there is an upward trend in the temperature of the mill room and a slight decrease in humidity during any given day. There is also a downward trend in the moisture content of the mill products for each day, those from the first sample in particular having an appreciably higher moisture content.

From the data given in tables 1 and 2, the yield of mill products was calculated to a dry matter basis, and the results recorded in table 3.

By reference to the total by-products column it will be observed that, in every case, the first milling (when the rolls were cold) gave the lowest yield of total by-products for that particular day, while, in general, the first milling also gave the highest yield of flour and the highest total returns. A higher total return, obtained by direct weighing of the mill products, might be expected for the first milling since at the beginning ,the rolls are cold and thus the relative humidity of the air at the rolls would more closely approximate that of the room than in the case of subsequent samples, resulting in a higher moisture content of all the mill products for the first sample. An increased yield of flour and total returns in terms of dry matter, however, is rather astonishing and is probably due to the stocks, when cold, clinging less readily to the tin hopper below the rolls. Whatever the cause, calculations made from the milling data presented above, show that the first milling deviates more from the mean than any of the other millings of the day.

TABLE 1. *Milling data in per cent.* (*On conditioned moisture content basis*).

No.	Bran	Shorts	Total By-Products	Flour Patent	Total Flour	Total Products
	%	%	%	%	%	%
1	14.45	12.45	26.90	54.37	72.50	99.40
2	14.69	12.62	27.31	54.29	72.38	99.69
3	14.83	12.12	26.95	54.53	72.71	99.66
*4	13.80	12.34	26.14	55.85	74.48	100.62
5	14.18	13.03	27.21	54.67	72.89	100.10
6	14.29	12.76	27.05	54.59	72.78	99.83
7	13.81	12.88	26.69	54.54	72.72	99.41
8	14.48	12.51	26.99	54.38	72.51	99.50
9	14.13	13.10	27.23	54.16	72.21	99.44
10	14.35	12.62	26.97	54.31	72.41	99.38
*11	13.88	12.56	26.44	55.21	73.61	100.05
12	14.10	12.97	27.07	54.55	72.73	99.80
*13	13.60	12.77	26.37	55.86	74.48	100.85
14	14.23	13.04	27.27	54.52	72.70	99.97
15	14.51	12.64	27.15	54.44	72.5	99.73
16	14.60	12.53	27.13	54.55	72.73	99.86
17	14.53	12.71	27.24	54.15	72.21	99.45
18	14.55	12.74	27.29	54.35	72.47	99.76
19	14.96	12.31	27.27	54.73	72.98	100.25
*20	13.80	12.85	26.65	55.54	74.05	100.70
21	14.17	12.82	26.99	54.63	72.94	99.93
22	14.82	12.13	26.95	54.77	72.37	99.32
23	14.75	12.14	26.89	54.64	72.90	99.79
24	14.05	12.79	26.84	54.75	72.33	99.17
25	14.07	12.74	26.81	54.38	72.51	99.32
26	13.91	12.91	26.82	54.44	72.58	99.40
*27	13.43	11.81	25.24	56.38	75.18	100.42
28	13.23	12.02	25.25	55.48	73.98	99.23
29	14.04	12.30	26.34	54.72	72.96	99.30
30	14.11	12.02	26.13	54.64	72.85	98.98
31	13.73	12.00	25.73	54.64	72.85	98.58
32	14.29	11.64	25.93	54.64	72.85	98.78
33	14.50	12.21	26.71	53.92	71.89	98.60
*34	13.88	12.55	26.43	55.36	73.81	100.24
35	15.20	11.81	27.01	54.47	72.63	99.64
36	14.94	12.25	27.19	54.11	72.14	99.33
37	15.29	12.37	27.66	53.93	71.90	99.56
38	14.56	11.73	26.29	54.66	72.89	99.18
39	14.62	12.31	26.93	54.11	72.15	99.08
40	15.08	12.08	27.16	53.95	71.94	99.10
41	14.70	12.43	27.13	54.09	72.12	99.25
*42	13.94	13.03	26.97	54.43	72.58	99.55
43	14.04	12.70	26.74	54.37	72.50	99.24
44	14.10	13.02	27.12	54.10	72.13	99.25
45	14.15	12.95	27.10	54.16	72.21	99.31
46	14.26	12.41	26.67	54.13	72.18	98.85
47	14.35	12.51	26.86	54.33	72.44	99.30
*48	13.55	12.56	26.11	55.57	73.76	99.87
49	14.04	12.76	26.80	54.57	72.76	99.56
50	14.23	11.71	25.94	54.52	72.69	98.63

*First sample milled each day.

TABLE 2. *Moisture content of mill products.*

No.	Bran	Shorts	Flour		Temp. of Mill Room	Relative Humidity
			Patent	Clear		
	%	%	%	%	°F	%
1	13.32	13.08	13.80	14.10	70	69.5
2	13.43	12.93	13.80	14.19	72	71.0
3	13.16	12.90	13.92	14.15	72	70.0
*4	13.81	13.64	14.29	14.22	66	72.0
5	13.75	13.48	14.22	13.97	70	73.0
6	13.69	13.26	13.99	14.08	71	71.0
7	13.35	12.88	13.60	13.69	72	69.5
8	13.37	12.76	13.30	13.71	72	70.0
9	13.36	12.86	13.27	13.84	73	70.0
10	13.35	12.89	13.41	13.76	73	69.5
*11	14.21	13.89	13.85	14.27	63	75.0
12	13.69	13.33	13.50	13.98	69	72.5
*13	14.03	13.89	13.99	14.40	68	75.0
14	13.85	13.46	13.71	13.99	70	74.0
15	13.36	13.20	13.58	13.89	72	73.0
16	13.51	13.07	13.90	14.01	73	71.0
17	13.51	13.02	13.72	13.58	73	71.5
18	13.48	12.90	13.57	13.52	73	73.0
19	13.39	12.86	13.73	13.51	74	72.0
*20	14.23	13.64	14.18	13.96	70	74.0
21	13.62	13.02	13.62	13.65	72	70.0
22	13.55	12.77	13.71	13.44	72	70.0
23	13.11	12.52	13.61	13.31	72	70.0
24	13.24	12.62	13.46	13.40	73	70.0
25	13.14	12.44	13.32	13.37	73	68.5
26	12.96	12.47	13.31	13.28	73	70.0
*27	13.59	12.67	13.65	13.47	69	69.0
28	13.11	12.45	13.20	13.47	70	65.0
29	13.40	12.59	13.51	13.39	71	66.0
30	12.83	12.07	13.18	13.55	72	61.0
31	12.88	11.62	12.89	13.17	72	61.0
32	12.98	12.03	13.18	13.63	72	59.0
33	13.27	12.38	13.46	13.85	73	62.0
*34	14.06	13.45	14.00	14.36	68	68.5
35	14.08	13.42	13.91	14.36	71	70.5
36	13.83	12.75	14.23	14.21	72	69.0
37	13.99	12.75	14.18	13.91	72	67.5
38	13.63	12.65	13.89	13.87	73	66.0
39	13.57	12.59	13.84	14.15	74	69.0
40	13.91	12.87	13.84	14.10	74	69.0
41	13.67	12.73	13.75	13.98	74	67.5
*42	14.11	13.49	14.23	14.47	71	71.0
43	13.64	12.76	13.92	14.14	73	71.0
44	13.95	12.69	13.90	14.10	73	71.0
45	13.52	12.59	13.75	13.97	73	70.0
46	13.69	12.58	13.83	14.16	74	69.0
47	13.41	12.39	13.74	13.95	74	69.0
*48	14.17	13.45	14.31	14.48	68	70.0
49	14.08	13.17	14.07	14.42	72	70.5
50	13.50	12.59	13.89	13.96	72	70.5

*First sample milled each day.

TABLE 3. *Mill products in per cent. (Dry matter basis).*

Sample	Bran	Shorts	Total By-Products	Flour		Total Products
				Patent	Total	
	%	%	%	%	%	%
1	14.40	12.44	26.84	53.87	71.77	98.61
2	14.62	12.63	27.25	53.79	71.63	98.88
3	14.80	12.13	26.93	53.96	71.90	98.83
*4	13.67	12.25	25.92	55.02	73.40	99.32
5	14.06	12.96	27.02	53.90	71.92	98.94
6	14.18	12.72	26.90	53.96	71.94	98.84
7	13.75	12.90	26.65	54.17	72.20	98.85
8	14.42	12.55	26.97	54.19	72.18	99.15
9	14.07	13.13	27.20	53.99	71.86	99.06
10	14.29	12.64	26.93	54.05	71.99	98.92
*11	13.68	12.43	26.11	54.67	72.80	98.91
12	13.99	12.92	26.91	54.23	72.21	99.12
*13	13.44	12.64	26.08	55.22	73.54	99.62
14	14.09	12.97	27.06	54.08	72.05	99.11
15	14.45	12.66	27.11	54.07	72.03	99.14
16	14.56	12.52	27.08	53.98	71.95	99.03
17	14.45	12.71	27.16	53.70	71.64	98.80
18	14.47	12.75	27.22	54.00	72.00	99.22
19	14.90	12.33	27.23	54.27	72.41	99.64
*20	13.60	12.75	26.35	54.79	73.10	99.45
21	14.07	12.82	26.89	54.29	72.41	99.30
22	14.72	12.17	26.89	53.83	71.84	98.73
23	14.74	12.21	26.95	54.25	72.46	99.41
24	14.01	12.85	26.86	53.96	71.95	98.81
25	14.05	12.83	26.88	54.18	72.23	99.11
26	13.92	12.99	26.91	54.25	72.33	99.24
*27	13.34	11.86	25.20	55.96	74.66	99.86
28	13.22	12.10	25.32	55.36	73.75	99.07
29	13.98	12.36	26.34	54.40	72.55	98.89
30	14.14	12.14	26.28	54.53	72.63	98.91
31	13.75	12.19	25.94	54.71	72.88	98.82
32	14.29	11.77	26.06	54.53	72.61	98.67
33	14.45	12.30	26.75	53.63	71.43	98.18
*34	13.71	12.39	26.10	54.72	72.88	98.98
35	15.02	11.76	26.78	53.90	71.77	98.55
36	14.80	12.29	27.09	53.34	71.13	98.22
37	15.11	12.41	27.52	53.64	71.43	98.95
38	14.45	11.78	26.23	54.10	72.14	98.37
39	14.52	12.37	26.89	53.59	71.39	98.28
40	14.92	12.10	27.02	53.43	71.19	98.21
41	14.59	12.47	27.06	53.63	71.45	98.51
*42	13.76	12.95	26.71	53.67	71.50	98.21
43	13.94	12.73	26.67	53.80	71.68	98.35
44	13.95	13.06	27.01	53.54	71.34	98.35
45	14.06	13.01	27.07	53.69	71.55	98.62
46	14.14	12.47	26.61	53.62	71.43	98.04
47	14.29	12.60	26.89	53.87	71.78	98.67
*48	13.37	12.49	25.86	54.73	72.61	98.47
49	13.87	12.74	26.61	53.90	71.79	98.40
50	14.15	11.77	25.92	53.96	71.93	97.85

* First sample milled each day.

Statistical Analysis of Milling Data

The milling data given in tables 1 and 3 were subjected to statistical analysis and the constants recorded in table 4.

The mean recovery of 99.54 per cent on the conditioned basis corroborates Shollenberger's data (*loc. cit.*) on the relation between the original moisture content of the wheat and relative humidity of the mill room to total returns. (The mean loss of 0.46 per cent corresponds to a loss of 9.2 grams). On the dry matter basis the mean recovery was 98.66 per cent, representing a loss of 23.32 grams (1.34 per cent of 1740) dry matter.

The coefficient of variability in the yield of bran was greater than for any of the other mill products. The variability of the total by-products is considerably less than that of its components, due to the fact that an increase in the yields of the one generally results in a decrease in that of the other.

The variation in the yield of total flour (expressed on either the conditioned or dry matter basis) was 0.95 per cent. This corresponds to a variation in yield of 19.0 grams (0.95 per cent of 2000) on the conditioned basis, and 16.53 grams (0.95 per cent of 1740), on the dry matter basis.

It will be noted that the yield of total flour was 0.63 per cent higher when expressed on the conditioned basis. In order to determine whether this relatively small difference is significant, the ratio of the difference in the mean yields to the probable error of the mean difference was calculated. The formula used for calculating the probable error of the mean difference was:

$$E\left(\bar{c}-\bar{d}\right) = 0.67449\sqrt{\frac{\sigma_c^2+\sigma_d^2-2\,r_{cd}\,\sigma_c\,\sigma_d}{N}}$$

where c and d represent the total flour yield on the conditioned and dry matter basis respectively and the other symbols have their usual significance.

The value of r_{cd} * was found to be $+\ 0.75 \pm 0.04$ and the value of the ratio $\frac{\left(\bar{c}-\bar{d}\right)}{E\left(\bar{c}-\bar{d}\right)}$ to be 13.8. The difference in mean flour yield expressed on the two bases is therefore significant. However, the coefficient of variability is 0.95 per cent in each case and the difference in flour yield is consistent as indicated by the high coefficient of correlation. It must be pointed out, however, that a variability of 0.95 per cent represents a variability of 19.0 and 16.5 grams in flour yield on the conditioned and dry matter basis respectively.

A slight increase in accuracy may, therefore, be effected by calculating flour yields on a dry matter basis, but from practical considerations it seems doubtful whether the slightly greater accuracy justifies the extra time and labour involved in running moisture determinations, where control is exercised in maintaining the temperature and humidity of the mill room within fairly narrow limits.

The question then naturally arises as to the relative importance of variations in the temperature and the relative humidity of the mill room on flour yields calculated from the conditioned basis. Simple and partial correlations between these three variables were computed with the following results. (c — designates flour yield conditioned basis; t — the temperature and h — the relative humidity of the mill room).

*The correlations given in this paper were computed, using the formula proposed by Harris (Amer. Nat., 44, 693, 1910).

TABLE 4. *Statistical Constants for per cent Yield of Mill Products — Conditioned Basis vs. Dry Matter Basis*

Statistical Constant	Bran		Shorts		Total By-prod.		Patent		Total Flour		Total Products	
	Conditioned Basis	Dry Matter Basis	Conditioned Basis	Dry Matter Basis	Conditioned Basis	Dry Matter Basis	Conditioned Basis	Dry Matter Basis	Conditioned Basis	Dry Matter Basis	Conditioned Basis	Dry Matter Basis
Mean ($\bar{X}$)	14.28	14.18	12.48	12.50	26.76	26.68	54.61	54.14	72.78	72.15	99.54	98.66
Stand. Dev. σ	±0.447	±0.448	±0.387	±0.363	±0.405	±0.501	±0.526	±0.514	±0.694	±0.688	±0.508	±0.431
Prob. error of single determin. (E_S)	±0.301	±0.302	±0.261	±0.245	±0.273	±0.338	±0.355	±0.347	±0.468	±0.464	±0.343	±0.290
Prob. error of mean (E_M)	±0.043	±0.042	±0.037	±0.035	±0.038	±0.048	±0.050	±0.049	±0.066	±0.066	±0.048	±0.041
Cœffic. of variation (C_V)	3.13%	3.16%	3.10%	2.90%	1.51%	1.88%	0.96%	0.95%	0.95%	0.95%	0.51%	0.44%
Prob. error of cœffic. of variation (E_{CV})	±0.030	±0.030	±0.026	±0.036	±0.027	±0.034	±0.035	±0.035	±0.047	±0.046	±0.034	±0.029

		Simple Correlations	Partial Correlations
r_{ch}	=	+ 0.175 ± 0.09	
r_{ct}	=	— 0.78 ± 0.04	${}_{t}r_{ch} = -0.08 \pm 0.09$
r_{ht}	=	— 0.27 ± 0.09	${}_{h}r_{ct} = -0.78 \pm 0.04$

The low and insignificant partial correlation between flour yield and humidity, for constant temperature, and the high and significant negative correlation between flour yield and temperature for constant humidity indicate that the variation in temperature of the mill room has a much greater influence on the yield of flour than the relatively small variations in humidity which occurred during the milling of these samples. These results suggest the advisability of locating the mill in a room where variations in temperature will be at a minimum.

Assuming that the mean result of fifty millings constitutes a reliable milling test the question arises as to the number of samples one would have to mill in order to approach any desired accuracy. By reference to table 4, it is observed that the probable error of a single determination of total flour (conditioned basis) is 0.468 per cent or 9.36 grams. In other words the results of a single determination may be expected to differ from the mean value by ± 9.36 grams in 50 per cent of the cases. If this figure is multiplied by 3.2 (yielding a value of ± 29.95 grams) the ratio of values from single determinations falling within and without the limits of ± 29.95 grams is 30 to 1; that is, one would be reasonably sure in making a single milling that the results will not differ from the assumed true value by more than 29.95 grams. The expected accuracy obtainable by a single determination can hardly be regarded as satisfactory, since an error of ± 1.50 per cent, in the yield of total flour, would in many instances obscure inherent differences in the milling value of wheat samples. This error is reduced by replication of the milling test in proportion to the square root of the number of samples milled. Calculations of the maximum expected difference in flour yield, expressed on both bases, were made for one to 13 millings and the results recorded in table 5.

TABLE 5. *Maximum expected difference in flour yield from the mean of fifty millings.*

No. of Millings	Conditioned Basis	Dry Matter Basis
	Grams	Grams
1	±29.95	±25.82
2	±21.18	±18.27
3	±17.28	±14.91
4	±14.98	±12.90
5	±13.41	±11.55
6	±12.22	±10.53
7	±11.33	± 9.76
8	±10.59	± 9.12
9	± 9.98	± 8.61
10	± 9.47	± 8.16
11	± 9.02	± 7.78
12	± 8.64	± 7.46
13	± 8.32	± 7.17

It should be recalled that these computations are based on statistical data calculated from all the samples and if the first milling for each day were discarded the variability would be considerably reduced.

Summary

A statistical study was made of the milling data obtained by 50 replicate milling tests of a sample of western Canadian hard red spring wheat grading No. 1 Northern, which was conditioned to a moisture content of 13.0 per cent before tempering. An effort was made to control the relative humidity of the mill room at 70 per cent. Moisture determinations were made on all the mill products and the yields expressed on both the conditioned and dry matter basis.

A mean recovery of 98.6 per cent of the total dry matter was obtained, representing a loss of 23.3 grams dry matter in a 2000 gram milling sample (containing 13.0 per cent moisture).

The first sample milled each day gave a higher extraction of flour on the dry matter basis and the mill products possessed a higher moisture content than subsequent samples milled on the same day. These results suggest the advisability of warming up the rolls prior to milling.

Flour yields expressed on the conditioned basis were consistently higher than when expressed on the dry matter basis. The coefficient of variability expressed in grams was slightly greater for the conditioned basis. The difference, however, is not considered sufficient to justify the running of moisture determinations when the milling is done under controlled conditions.

Variations in temperature of the mill room had a much greater effect on the flour yield (conditioned basis) than the relatively small variations in humidity, which occurred during the milling of the samples. These results suggest the advisability of locating the mill where temperature fluctuations will be at a minimum.

The odds are 30 to 1 that single millings will give total flour yields which will not vary more than $\pm$ 29.9 grams (conditioned basis) or $\pm$ 25.8 grams (dry matter basis) from the mean of 50 millings.

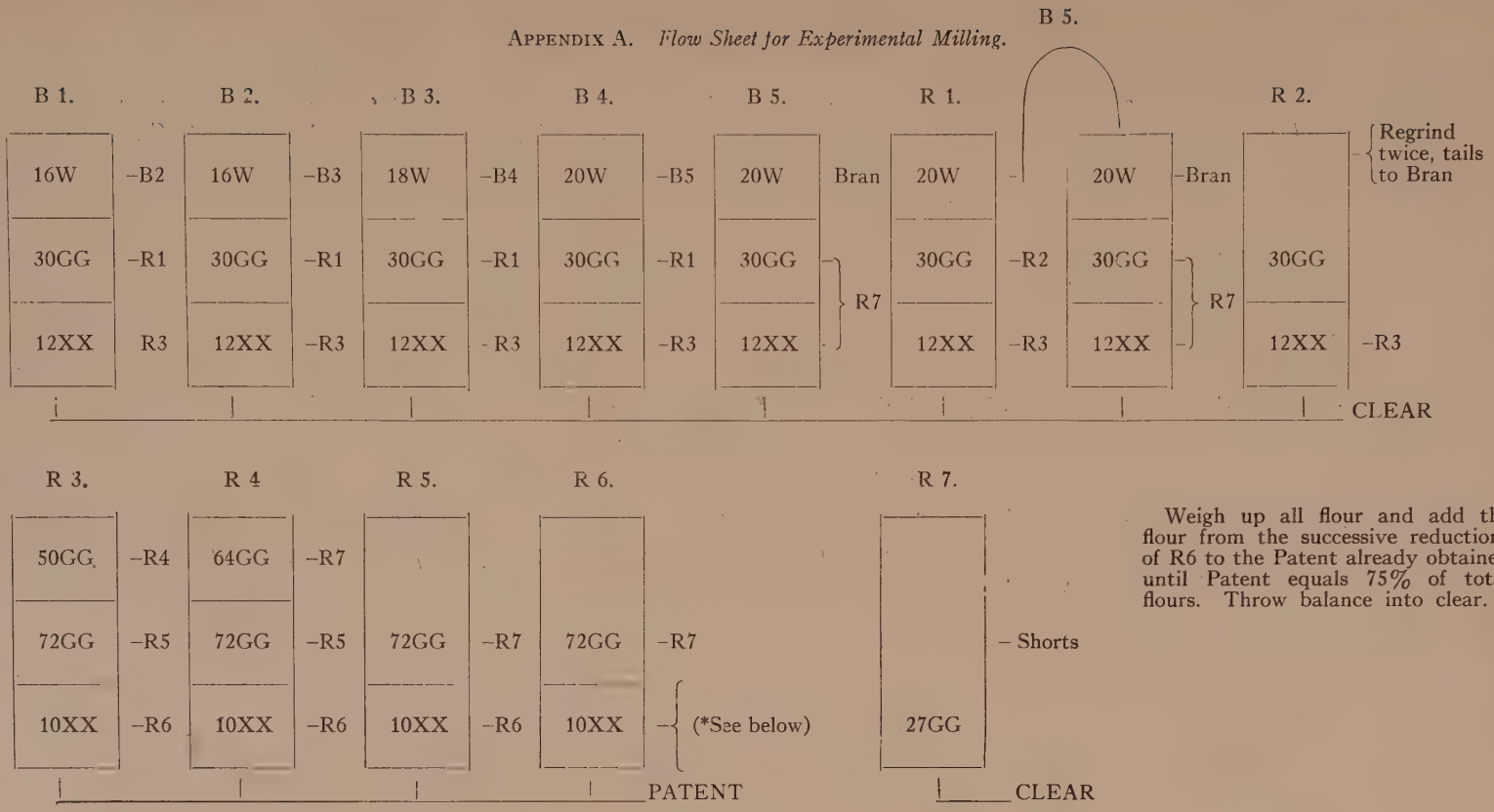
Acknowledgements

The authors wish to acknowledge the financial assistance of the National Research Council of Canada, which rendered this work possible, and are also indebted to Dr. C. H. Goulden, Cereal Specialist, Dominion Rust Research Laboratory, Winnipeg, for assistance with the statistical portion of this paper.

LITERATURE CITED

1. Bailey, C. H. The chemistry of wheat flour (p. 128) Chemical Catalog Company.
2. Shollenberger, J. H. The influence of relative humidity and moisture content of wheat on milling yields and moisture content of flour. U. S. Dept. Agric. Bul. 1013.

APPENDIX A. *Flow Sheet for Experimental Milling.*



Weigh up all flour and add the flour from the successive reductions of R6 to the Patent already obtained until Patent equals 75% of total flours. Throw balance into clear.

*Grind to 75 per cent Patent until sufficient obtained
Keep Patent from each regrinding separate.

NOTES.

BEACON LIGHTS FOR PROFESSIONAL AGRICULTURE*

H. Barton †
Macdonald College, P.Q.

I am highly honored indeed, in being asked to speak to the O.A.C. Alumni Association and the C.S.T.A. on an occasion such as this, and I am very happy to have this opportunity to register once more as an alumnus of the O.A.C., mother of agricultural colleges and cradle of professional agriculture in Canada. Long may we cherish her. I should like to say on this occasion that I am sure it is with the fullest confidence that we look forward at this time to her continued prosperity under the able direction of Dr. Christie. The O.A.C. has done much for many of us. We all owe a great deal to the men who made that institution and, coming as I do from a younger college, it is with a deep sense of gratitude that I join with you at this time in paying just tribute to the Ontario Agricultural College.

This being a joint banquet, I must not fail to recognize the C.S.T.A. To my mind the Canadian Society of Technical Agriculturists represents the only form that such a society could take in Canada to be of real service to professional agriculture. It has brought us together as nothing else could have done, and there was great need for that. What a pity it would be for the O.A.C. Alumni Association to hold a meeting of its own at a time like this. Those in charge of the programme very wisely planned it as a social event, and it is too bad to have it interrupted by a speech from me. That is the only mistake the Committee made. By virtue of the C.S.T.A. many of us have become conscious of the fact for the first time that we are members of a profession. It has done much to elevate our calling to the status of a profession and, at a time when it was overdue, to give it some measure of solidarity. It has done many other things but I shall not enumerate them. President Sackville is doing that in very able fashion during his visits to the various branches. My prediction is that the influence and service of the C.S.T.A. will continue to grow in the years to come.

And now let us look at the profession to which we belong. A useful profession, all will agree, and perhaps all will admit, composed of hard, conscientious workers. Apparently there is unanimity in that, Mr. Chairman. I am prepared to go further and to state that I am bound to believe that no class of men has given more unselfish devotion to the cause they serve. And with what result? We have made a contribution; we have gained respect, some appreciation and some esteem; not lucrative positions, nor have we won the power possessed by other professions, professions no less worthy but certainly no more vital to the interests they represent.

True, ours is still a young profession, less than fifty years old, consciously at any rate, whereas others like law and medicine have centuries behind them. Even engineering had its institution of civil engineers more than a hundred years ago.

*Address given at the O.A.C. Alumni-C.S.T.A. Banquet held at Toronto, Ont., on November 22, 1929.

†Dean of the Faculty of Agriculture, McGill University.

One other great difference is that ours is not a closed profession. All who knock may enter by some door or other. One need only point to the feature articles in the popular press at the present time, articles dealing with matters of great importance to agriculture and, strange as it may seem, rarely written by men who have to do with either the practice or profession of it. Can you imagine articles on law, engineering and medicine, popular if you will, written by every Tom, Dick and Harry. I submit that if others are presuming to speak for us in informing public opinion it is because we are not sufficiently articulate and aggressive ourselves.

Nor has our profession taken the form of private practice. This is another disadvantage which it suffers beside other professions. It is largely a public service; we too are under that popular institution known as Government control. It has been given that form, presumably like other things under Government control, because it was deemed necessary and considered to be in the interests of the country to have it so, and hence we are not entirely independent. Unlike some other things under Government control, however, the price of our commodity is extremely low. There is no incentive for bootlegging. Perhaps it is just as well and for much of the work it is not likely to change.

But there are developments in other directions. As a result of the changed conditions even farmers are grouping together to employ the services of men with training in agriculture, and commercial business is now discovering the need for such men. Here to my mind is one of the most significant developments, one of the brightest lights beckoning to our profession. It has only begun to shine but there is no mistaking it. We shall do well to remember that a great deal of the business of this country has to do directly with agriculture and that, thanks very largely to the services of the agricultural profession, the people engaged in agriculture have to be approached differently and dealt with differently than was formerly the case, and business is finding this out. I would remind you also that much of the centralized business in agriculture was developed from small beginnings by men who came from the farm, a generation that is now passing and being superceded in many cases by men who know little or nothing of the farm, who have little understanding of it and too often little sympathy for it, except in so far as it may be necessary to insure a supply of raw material at a price that will allow the necessary profit for themselves. Business today is demanding educated men. Right in this city of Toronto, the incorporating each year of a few University trained men in a particular business is not an unknown policy, and where are these men coming from, even for agricultural business? Fortunately now, to a very small extent, from the ranks of agriculture; largely, however, from the ranks of men with other training, men educated in an atmosphere where, shall we say, agriculture receives scant if any consideration. We all know that business relations between the farm and the commerce and industry that arise out of it are necessarily becoming more intimate, in fact they are becoming interwoven. One of the gaps that is hardest to close is that of mutual understanding, mutual confidence, mutual goodwill and, what is perhaps even more important, mutual service, because I hold that to be perfectly possible. What better

preparation could a man have for such service, for an influential part on either side, the farm or the business, than a university course, with a sound foundation in economics and a comprehensive knowledge of agriculture, and what better opportunity could be offered to a farmer's son who does not propose to farm?

I find no fault with the man who can afford a university course who wants to invest it in farming and farm life. There is plenty of opportunity and it is growing. Such men are an asset to the farming business; we need more of them and through the transition now in effect I believe we shall have more of them. I am not forgetting the great field in science, technical work, and the various other services that beckon for still more help, but it does seem to me that in the new business conditions applying to agriculture, there is inviting opportunity for far-reaching service and that it is a field that we have every right and need to occupy.

When it comes to science, a field which we have not failed to appreciate, one in which we have made a contribution, but one which we have not always fully understood, I am afraid we must admit that in it, educationally and investigationally, unavoidably perhaps, we have done a bit of floundering. "Scientific Agriculture" has been a good slogan, and "Scientific Farming", not of our making, has been a sort of snare for public opinion, but not farmer opinion. We realize it is a misnomer; nobody has discovered it in practice. But science as an aid to farming and the industries that are built upon it is absolutely essential and imperative. Before we can go on with much of the work we would like to do, we must wait for science. I would remind you again, that we are a young profession, we have had many demands, the problems that face us are often extremely complex, and while we have no reason to be ashamed of our record, it is not surprising that we have been overwhelmed. We have borrowed freely from others, we have welcomed men from other ranks to ours and it may be necessary for us to continue to do so. Our men too have gone in other directions but we must make our profession, its product of science training in agriculture stand for the best in science. That means thorough and extensive fundamental work. In this, as in other branches of our work, our vision is becoming clearer, we can see a lot farther than we could. All honor to the men who have accomplished things in spite of the shortcomings. They did it in many cases with a poor tool kit, and despite this handicap they managed to construct a satisfactory foundation for what is to come. But training alone will not suffice for the bigger things in science. We must discover those who have a genius for research and as they are discovered they must be given unfettered opportunity. One thing more I would add, we must cultivate the spirit of coöperation that some of us have preached so emphatically to others. Our most perplexing problems are likely to have many ramifications; they cannot be tackled single handed, nor can science alone always deal with them. What is more, we have few if any organizations strong enough to attack them successfully without pooling their personnel and their resources. But we can go beyond that. Someone has said that science has no boundaries. Let us see to it that there are no artificial and needless boundaries, no Dominion boundaries, no provincial boundaries, no college boundaries, no departmental boundaries

in research or in any other service our profession undertakes to perform. I am not unmindful of the need for personal incentive and freedom, but this little idea of credit should not be allowed to dominate our plans nor to frustrate our efforts. To use the well known quotation from Disraeli—"Life is too short to be little" and to paraphrase it if I may, in agriculture problems are too perplexing and too pressing to be entrusted to little people.

We are a very conservative, in fact extremely cautious, group of people. That is regarded as one of our assets; we have not ventured far away from our alloted tasks, unless recently when some of us have taken a few nibbles at the stock exchange, and now some of us have fewer assets. I hope this experience will not kill the spirit of adventure in other more appropriate directions; according to the lords of finance it should stimulate it. Surely in the tremendous commercial developmetnts and possibilities in agriculture there are investment fields which we can explore more intelligently and with more security. Many examples of conspicuous success could be given by all of us and some may say conspicuous failures too. We may expect some failure but surely we are not going to admit that in the field we know most about failure is inevitable or even probable. For purposes of illustration may I cite one case, a man of our own profession well known to many of us, successful in his job for a number of years, drawing a respectable salary but not large enough to promise independence. He longed for an enterprise of his own, but never had the courage nor as he said the "guts" to start anything, until finally, personal circumstances gave him the necessary push to make what seemed to him a great plunge, not in something foreign to him but in a type of enterprise with which he was familiar, one in which he could invest his capital, small in cash but large in personal knowledge with some security and hope of realizing on it. That, he has been able to do, and in a comparatively short time, much to his financial advantage and greatly to his personal satisfaction. An interesting thing about his case is that once started on a business basis he had no difficulty in obtaining all the capital he needed.

Where there is no adventure we may expect stagnation. To be adventurous it is not necessary to be rash; it often involves more courage than cash, and I would like to say to the younger men, don't allow your courage to freeze up through cold feet and become an object of sympathy, camping on a job, and expecting that by virtue of possession, and length of service, you will be entitled to promotion and increase in salary. If you are not entitled to these on other grounds you should be in something else for your own good as well as that of other people and to keep the profession healthy.

We have established extensive service machinery for the development of agriculture in this country and we are adding to it all the time. It has been built to operate in two fields chiefly, production and marketing. Within the limits of its possibilities, it has proved an efficient machine but it must be adapted to new conditions as they arise. It has become so extensive now that it presents problems of both coördination and amalgamation, and its continued efficiency must depend upon how successfully these are brought about. They are not being overlooked; the C.S.T.A. has them under con-

sideration, individuals here and there are making them their concern and effecting some adjustment from time to time. Due care must be exercised that stability may not be sacrificed for the sake of change. There is great opportunity for leadership. In addition to careful study and sound judgment, it calls for broad minds and a measure of magnanimity.

But production and marketing, broadly as we may interpret them, do not encompass all the responsibilities of professional agriculture. The educational status of the people we are endeavoring to serve for instance, is surely of concern to us. Agricultural service by trained men has developed the capacity of the farmer but it has also been limited by it. It cannot rise any higher than the farmer's power of assimilation. In addition to this, there is the still broader aspect of education, education for living, without which no class of people can hope to enjoy the satisfactions that life has to offer. Farm boys, I regret to say, are not receiving it, and no class of men is in quite as good a position to recognize this fact and to develop an appreciation of it as are those in the agricultural profession. And yet, how many of us have given much thought to it, and what has been our contribution? Have we grasped the full meaning of living, ourselves? Leaders in every profession should continually ask themselves, "How can I better fit myself for my rôle in life?" We are virtually pioneers in this work, without traditions, without precedents, unfortunately faced too often with the spectres of suspicion and ignorance, and while the task of those who would blaze new trails in agriculture is not a simple one, it is, nevertheless, our task. Perhaps the greatest bugbear we have to face is the doctrine of utilitarianism. While not confined to the farmer by any means, the peculiar independence and isolation of the farmer has no doubt tended to inspire in him a passionate belief in material progress. Engulfed by a minor dilemma of life, the means of making a living, he too often ignores the major dilemma, "giving living a meaning". Some one has said that a man is known by his dilemmas. If there is anything in this statement, and I believe there is, let us first turn the search light on ourselves. Are we taking ourselves too much for granted? What are our dilemmas? Are they infantile or do they give evidence of maturity? Facing them fairly and squarely do we not find them deeply colored with a passionate desire to get on, to make a showing? Worthy as these motives are, they will not suffice to place our profession where we want to see it. If this be so, how can we hope to raise the plane of the farmers' dilemmas? Should we not review our own sense of values, our own choice of standards? What do we read? Some one said that the *Saturday Evening Post* satisfied all the intellectual and spiritual requirements of the commercial traveller. I should hope that could not be said of many of us. Are we really thinkers in the deeper things, in the sense that even some of our foreign friends are? What are our conceptions of the things most worth while for ourselves and for those we are trying to help? Without a sound philosophy for ourselves, we cannot hope to be of the highest service to others.

LA POMME DE TERRE (*Solanum tuberosum*)

F. Corminboeuf
Professeur au Collège de Gravelbourg, Sask.

I—*Historique*:

La pomme de terre est originaire des plateaux du Chili, du Pérou et du Mexique, où elle était cultivée par les sauvages avant l'arrivée des Espagnols.

Ceux-ci l'introduisirent d'abord en Espagne et en Italie, d'où elle passa en Autriche, en Belgique, enfin en France où elle fut vulgarisée par Parmentier.

En Angleterre, elle fut introduite directement d'Amérique, comme du reste en Irlande et dans les Iles Britanniques par Lord Rayleigh. Elle ne tarda pas à devenir la base de l'alimentation des Irlandais, si bien que les ravages causés à sa récolte par le mildiou durant les années de 1839 à 1841 obligèrent un grand nombre d'Irlandais à émigrer vers des contrées nouvelles.

II.—*Importance économique*:

D'après les statistiques de l'Institut International d'Agriculture de Rome, la production mondiale de la pomme de terre a été comme moyenne des années de 1915 à 1919 de 2,525,143,000 boisseaux par année, répartis comme suit:

Europe	89.5%
Amérique du Nord	8.0%
Asie	1.1%
Amérique du Sud	0.9%
Australie	0.4%
Afrique	0.1%

La récolte mondiale annuelle se trouve utilisée comme suit:

Alimentation humaine	28 %
Alimentation du bétail	40 %
Semences	12 %
Rebut	10 %
Fabrication de l'alcool, de l'amidon et de produits divers	10 %

La superficie totale cultivée en pommes de terre au Canada était en 1920 de 534,621 acres répartis comme suit:

Ile du Prince-Edouard	32,282
Nouvelle-Ecosse	34,507
Nouveau-Brunswick	64,536
Québec	146,821
Ontario	156,082
Manitoba	26,841
Saskatchewan	31,463
Alberta	23,917
Colombie Anglaise	18,172

III.—*Ses exigences sous le rapport du climat*:

La pomme de terre est notamment bien adaptée aux climats frais et humides. Aussi, les meilleures régions pour sa culture ne dépassent guère 45°-isothermes. La période critique de sa végétation a lieu de la fin juillet au milieu d'août. A l'Université Cornell (Etat de N.Y.) on a entrepris d'enregistrer l'influence des principaux facteurs climatériques. (températures et précipitations) sur le rendement. Les résultats obtenus sont significatifs et nous démontrent les faits suivants:

1o—Sous un climat chaud et sec, 4 rendements ont été supérieurs à la moyenne contre 10 inférieurs.
2o—Sous un climat chaud et humide, 3 supérieurs et 10 inférieurs.
3o—Sous un climat frais et sec, 7 supérieurs contre 7 inférieurs.
4o—Sous un climat frais et humide, 14 supérieurs contre 3 inférieurs.

La distribution de l'eau est un facteur très important. Réduite à la fin de la période de végétation, elle doit être abondante, régulière au commencement de la végétation et surtout lors de la formation des tubercules.

IV.—*Ses exigences sous le rapport du sol*:

La pomme de terre vient bien sur une grande variété de sols. Aussi, les sols sablonneux assez riches en matières organiques, les loams donnent généralement de bons rendements. Les sols des tourbières (terres noires) donnent de très fortes récoltes lorsqu'ils ne sont pas trop acides. Par contre, les terres de sable ou d'argile pures sont peu adaptées à cette culture à moins qu'elles soient bien amendées, les premières par l'apport de matières organiques sous forme de fumier, les dernières par l'apport de fumier et de chaux.

Dans l'Etat du Maine, des expériences ont été poursuivies dans le but de mesurer l'influence du sol sur le rendement. Les résultats suivants ont été obtenus:

Varietes	Sols	Nombre de tuberculoses par plante	Rendement de boisseaux par are
Montagne verte	Tourbieres	8.6	475
	Graveleuses	8.3	456
Type rural	Loams	6.9	432
	Limons	6.3	422

La nature du sol peut aussi avoir une influence sur les maladies et la forme des tubercules.

V.—*Ses exigences sous le rapport de la culture*:

Dans cet ordre d'idées, il y a à considérer deux genres d'opérations.
1—Les travaux de préparation du sol destiné à recevoir la semence.
2—Les travaux de culture pendant la végétation.

La pomme de terre est très sensible aux divers modes de préparation du sol ainsi que le démontrent les expériences suivantes conduitent quatre années durant à Saskatoon:

Traitements du sol	Rendements boisseaux par acre.
Labour d'ete	228
Cassage	215
Labour d'automne	189
Retour de ble	179
" de lin	205
" de pois	221
" de plantes-racines	211
" de ble d'inde	249

Ces chiffres sont significatifs. Ils nous démontrent d'une façon incontestable que la culture et le mode de préparation du sol aboutissant au meilleur ameublissement de celui-ci fournissent, toutes choses étant égales ailleurs, les rendements les plus élevés.

Ainsi en est-il lorsque la pomme de terre est précédée d'un labour d'été ou d'une culture de blé d'Inde. Ceci s'explique en partie du fait qu'un sol ameubli profondément assure une bonne réserve d'humidité (facteur très important sous notre climat) en même temps qu'une meilleure aération du sol; conditions indispensables pour obtenir d'une récolte de pommes de terre la maximum de rendement.

Pour ce qui concerne le deuxième genre d'opérations, soient les travaux de culture pendant la période de végétation, nous pouvons les résumer en trois mots, (roulage, hersages, binages).

Le roulage est rarement nécessaire, les hersages après la plantation, avant la levée des plants, sont surtout nécessaires sur les sols qui durcissent facilement.

C'est généralement le cas de la majorité des terres de notre région qui sont franches, franches-argileuses ou argileuses.

Quant aux binages, ils doivent se pratiquer depuis la levée des plants jusqu'à ce que le feuillage recouvre une partie du sol. Ils doivent être assez profonds au début et plutôt superficiels vers la fin. Une bonne pratique est des les répéter au besoin toutes les deux ou trois semaines.

VI. *Variétés désirables.*

Depuis 200 ans environ que se pratique la culture de la pomme de terre, le nombre de ses variétés s'est considérablement accru.

Ainsi en 1771, il n'y en avait que deux variétés: les rouges et les blanches. En 1872 il en existait déjà 212, et en 1902, le nombre des variétés cultivées était porté à 1200. C'est dire qu'il y a certainement aujourd'hui des variétés répondant aux exigences de sols, de climats et de marchés les plus variées.

Dans cet article nous nous bornerons à nommer les variétés qui sous les diverses conditions de sols et de climats de l'Ouest, ont donné les meilleurs rendements, car en somme, c'est bien sur le rendement qu'il faudra d'abord se baser pour pouvoir se prononcer en faveur de telle ou telle variété. Il est évident que les variétés qui ont donné dans une région en particulier de bonnes récoltes sont celles qui correspondent le mieux aux exigences de cette région tant sous le rapport du climat et du sol que sous celui des maladies.

Dès lors, nous qualifierons de variétés désirables pour une région, celles qui ont donné les plus hauts rendements à la Station Expérimentale de la région considérée tels que nous les indique le tableau suivant publié par Macoun:

Varietes	Brandon bois	Indian Head bois	Saskatoon bois	Scott bois	Rosthern bois	Lethbridge bois	Lacombe bois
Irish Cobbler		364				341	
Dalmony Beauty						352	
Table Talk	407	353		304		424	
Woodbury White Rose	405						
Late Puritan					438		
Houlton Rose		385	267				
Early Notrhern							414
Everett			267		498		
Early Ohio				293			
Morgan Seedling				337		343	408
Dreer Standard		372			512		
Gold Coin		413		292		361	
Carman No. 1			279	284			
Empire State						344	439

VII. *Maladies*:

La pomme de terre a ses ennemis spécifiques comme la plupart des plantes cultivées. Au Canada, pas moins d'une dizaine de maladies s'attaquent à la pomme de terre et causent des dégats énormes à sa culture. Ainsi, en 1917, le mildiou, pour n'en citer qu'une, occasionnait des dommages dans Québec seulement, évalués à $75,000,000. Dans les provinces le l'Ouest, cette plante se trouve heureusement exempte de la plupart des maladies rencontrées ailleurs. Celles qui ont une importance économique et qui doivent par conséquent attirer l'attention des cultivateurs sont au nombre de deux, savoir:

1) la "jambe noire"
2) la "Rizoctonie"

1. *Jambe noire* (black leg)

La jambe noire est trés commune. Elle est due à l'action du Bacillus phytophtorus qui hiverne dans les tubercules, probablement aussi à la surface de ces derniers, dans les fanes et dans le sol.

Si l'on plante un tubercule atteint, les bactéries passent dans les germes lesquels peuvent être déjà détruits avant de sortir de terre. Si la plante réussit à croître, elle ne tarde pas à présenter les caractères suivants:

1—les feuilles jaunissent,

2—des tiges pourrissent, deviennent noires, d'où le nom bien descriptif de "jambe noire."

Les bactéries passent ensuite dans les tubercules nouveaux. Ceux-ci peuvent être détruits complètement ou bien ils ne présentent que des symptômes intérieurs: le coeur devient noir, décomposé, il se remplit de bactéries pathogènes pour l'année suivante.

Moyens de contrôle:

1—Lorsqu'il n'y a que quelques pieds de "jambe noire" parmi la récolte il vaut mieux les arracher et les détruire.

2—Lorsque la maladie est grave, il faut sélectionner la semence qu'on désinfecte ensuite en la plongeant pendant 1½ hrs, dans une solution de formaline (1 chopine pour 30 ou 40 gal. d'eau).

2. *Rizoctonie* (black speck) :

La Rizoctonie cause de sérieux dommages à la culture de la pomme de terre dans l'Ouest. Elle est due à l'action du Corticum Vagum, champignon saprophyte qui s'attaque à une grande variété de plantes, (betteraves, choux, radis, fèves, pois, etc.) Cette maladie peut être facilement caractérisée. Généralement, on trouve attachés à la surface des pommes de terre, des petits corps bruns de forme variable, d'une dimension oscillant entre la grosseur d'une tête d'épingle et un huitième de pouce de diamètre.

Ces corps, à l'état sec sont ordinairement peu visibles, mais si l'on mouille la surface du tubercule, ils apparaissent distinctement. Ce sont des masses de mycelium de repos, appelées communément sclérotes. Elles sont tout à fait superficielles et non associées à une pourriture ou à une autre affection du tubercule. Le mycélium qu'elles produisent peut causer une très grave maladie à la pomme de terre, à l'époque même de la plantation. Il attaque les racines, les tiges souterraines et même les tiges aériennes. Il y produit des taches brunes, déprimées, d'apparence chancreuse, qui parfois entourent toute la tige et la font se dessécher.

Cette attaque détruit fréquemment un grand nombre de tiges au moment où celles-ci font leur apparition au-dessus du sol. Quand les tiges ont atteint une bonne dimension mais que les racines ont été attaquées et détruites dans une large mesure, il se forme souvent à la base de la tige une grappe de petits tubercules. Cette forme de la maladies désignée sous le nom de "petites patates" s'associe généralement à la formation d'autres petits tubercules verts dans l'axe des feuilles. Cette formation anormale de petits tubercules est due à un surplus de sève fabriquée par les feuilles mais non utilisée par les tiges souterraines. Parfois, la maladie se manifeste par un raccourcissement de la tige; les feuilles sont serrées, enchevêtrées. La maladie due à cette espèce de champignon appartient au groupe connu sous le nom de "maladie du sol".

Cela veut dire que le champignon peut persister dans le sol pendant plusieurs années.

Moyen de contrôle:

1—Désinfecter les pommes de terre de semence avant de les couper en les laissant tremper pendant deux heures dans une solution de sublimé corrosif (14 oz. pour 30 gal. d'eau) ou dans une solution de formaline (1 chopine pour 30 gals. d'eau.)

2—Eviter de réensemencer un sol infesté avant plusieurs années.

VIII. *Insectes*:

La pomme de terre rencontre parmi les insectes un grand nombre d'ennemis avisés.

Mais dans l'Ouest, grâce à la rigueur du froid pendant l'hiver et à la faible quantité de neige, ceux-ci se trouvent en nombre restreint.

Il n'y a pratiquement qu'un seul insecte qui puisse se développer dans ces conditions et causer de réels dommages à la pomme de terre, c'est le Doryphora Decemlineata, connu sous le nom de "Bête à patates" ou de "Colorado potato beetle".

Depuis 1859, cet insecte exerce de très grands ravages sur les cultures de pommes de terre, aux Etats Unis et au Canada. Il ronge les feuilles à l'état adulte aussi bien qu'à l'état de larve et entraîne ainsi l'avortement des tubercules. L'insecte parfait apparaît en juin, l'accouplement et la ponte ont lieu presque aussitôt, les oeufs étant disposés par plaques jaunes à la face inférieure des feuilles. Deux autres générations se produisent en juillet et août, de sorte que cet insecte arrive à se multiplier d'une façon prodigieuse.

Moyen de contrôle:

1—Lorsque les insectes adultes apparaissent en très petit nombre, ils peuvent être enlevés à la main et détruits.

2—Lorsqu'ils apparaissent en grand nombre ils peuvent être contrôlés en arrosant le feuillage avec l'une ou l'autre des solutions suivantes
a) 1½ lbs. d'arséniate de plomb et 8 oz. de vert-de-Paris pr. 40 gal.
b) 1 lb. de chaux éteinte et 1 lb. de vert-de-Paris pour 80 gal.

3—On pourra aussi contrôler l'insecte en saupoudrant le feuillage, le matin à la rosée, avec un mélange composé de 1 lb. de vert-de-Paris et de 20 lbs. de chaux éteinte. Ce traitement a l'avantage de s'effectuer plus rapidement et requiert moins de travail.

IX. *Marchés et possibilité de l'extension de cette culture*:

Bien qu'il y ait généralement une forte demande de pommes de terre dans l'Ouest, tant sur les marchés locaux que sur ceux des villes, les cultivateurs semblent jusqu'ici s'être peu préoccupés de cette culture.

Cela tient à plusieures raisons dont voici les principales:

1—Difficulté de transport pour les producteurs éloignés du marché local et des stations de chemins de fer.

2—Manque d'organisations coopératives qui permettraient l'expédition de pommes de terre sur les grands marchés par wagons complets.

3—Manque également de coopération chez les producteurs qui seraient en mesure de satisfaire le marché local.

4—Les marchands ont de nos jours la facilité de s'approvisionner sur les grands marchés ou même dans l'Est, lorsqu'il s'agit d'un volume assez considérable.

Ces inconvénients d'ordre économique et social limitent l'extension de la culture des pommes de terre dans l'Ouest. Mais à tout mal tout remède; les cultivateurs qui se trouvent dans des régions propices à cette culture devraient essayer de réagir en présence d'un tel état de choses.

1o—En s'attachant à produire des tubercules uniformes et de bonne qualité, et cela—par le choix des variétés désirables, le contrôle des maladies et insectes.

2o—En se groupant afin de pouvoir atteindre à peu de frais les grands marchés—ou du moins, pour assurer aux marchands locaux le volume nécessaire.

LITTERATURE CITEE

1. Cours de Grande Culture de M. Vézina, prof. à l'Institut d'Oka. (Historique, exigences).
2. Cours de Phytopathologie du R. Père Léopold, directeur de l'Institut d'Oka (maladies de la pomme de terre).
3. Crop Production in Western Canada (John Bracken) (pp. 314-341).

BOOK REVIEW

THE AGRICULTURAL DEVELOPMENT OF ARID AND SEMI-ARID REGIONS, WITH SPECIAL REFERENCE TO SOUTH AFRICA. By H. D. Leppan, Professor of Agronomy, Transvaal University College, University of South Africa. (South Africa Central News Agency Limited, 1928. £1:5:0.)

This book is a valuable contribution to the study of agricultural conditions and development in arid and semi-arid regions. The author has studied conditions and practices in many countries and is able, therefore, to deal with the subject in a most comprehensive manner. A study of the book gives one a good general knowledge of the principles underlying the development of the various branches of agriculture, and of the importance of such influencing factors as physical controls, and biological, political and economic conditions.

The first six chapters are devoted to a study of conditions in South Africa. The author traces the development of agriculture from the time of the early settlement of the country by the Dutch East India Company, and then gives a brief statement of the problems connected with future farming development. It is shown that agricultural development is dependent chiefly upon such physical controls as climate, soil and topography. The effects of mineral discoveries, and of political and economic conditions are dealt with.

In chapter seven is given a summary of the most salient points of the preceding chapters. One outstanding conclusion is that, in South Africa, animal farming must predominate, and that since the animal population must remain restricted in numbers, progress in animal husbandry must be sought for chiefly in better breeding and feeding. The author faces the situation squarely, flinching not the truth. He finds that a general instability in the South African outlook tends to retard development. Then he turns his attention to other regions having somewhat similar physical conditions, and concludes that certain practices followed in other lands could be adopted profitably by the farmers of his own country. Chapter eight deals with conditions in the Bombay Presidency, chapter nine with those of Australia and chapters ten and eleven are devoted to a study of the arid and semi-arid portions of the United States. In chapter twelve is found a general discussion of the principles and common features of farming in arid and semi-arid countries, while in the following chapter is presented "A critical study of South African farming". Some of the topics dealt with are beef production, dairying, small stock, field husbandry, horticulture, forestry, irrigation, erosion, capital, labour, organisation and land tenure.

Other valuable features are the summaries given at the end of the chapters, the conclusions presented in chapter 14 and the many literature citations.

This book is well written, it is interesting and instructive and it is invaluable to those concerned with the agricultural development of arid and semi-arid regions. S.E.C.

CONCERNING THE C.S.T.A.

Horticulture Group

Chairman and Secretary for 1930

The Chairman of the Horticulture Group of the C.S.T.A. for 1930 is W. S. Blair, Dominion Experimental Station, Kentville, N.S., and the Secretary is A. Kelsall, Dominion Entomological Laboratory, Annapolis Royal, N.S. They will prepare the programme of the Horticulture Group for the Annual Convention of the C.S.T.A. which is to be held at Wolfville, N.S., in June, 1930, and make such other arrangements as are necessary in connection with the meeting of the Horticulture Group.

Names and Duties of Committees

A meeting of the Horticulture Group of the C.S.T.A. was held in Winnipeg at the time of the Annual Convention in June, 1929. At this meeting it was decided to organize Committees to deal with different phases of horticulture. These Committees were to report to the Group, from time to time, at the Annual Convention.

It was thought that a greater interest would be taken in the Horticulture Group, by members, if there could be sent, from time to time, to every member interested in horticulture, a report from one or more of these Committees.

Following are the names of the Committees and Chairmen with the duties of each:

1. *Control of Diseases and Insects*—Chairman, C. E. Petch, Dominion Entomological Laboratory, Hemmingford, P.Q.; the Committee on the Control of Diseases and Insects will give a report, from time to time, at the Annual Convention, on methods for the control of diseases and insects injurious to horticultural plants in Canada, with especial reference to those which are relatively new or of greatest interest. Such information will be later disseminated among horticultural members.

2. *Genetics*—Chairman, W. M. Fleming, Dominion Experimental Station, Summerland, B.C.; the Committee on Genetics will endeavor to keep abreast of the latest discoveries in genetics and also try to learn how these discoveries can be put in practice by horticulturists throughout Canada. This Committee will report, from time to time, at the Annual Convention, and the information given will afterwards be disseminated among the horticultural members.

3. *Historical Committee*—Chairman, R. P. Gorham, Dominion Entomological Laboratory, Fredericton, N.B.; the Historical Committee will record noted horticultural events in Canada, the origin of outstanding varieties of horticultural plants of Canadian origin, the work of Canadian horticulturists, living or dead, and will prepare suitable short biographies of Canadian horticulturists when they die. These to be presented in the form of a report, from time to time, at the Annual Convention, and later disseminated among horticultural members.

4. *Horticultural Education* — Chairman, F. W. Brodrick, Manitoba Agricultural College, Winnipeg, Manitoba; the Committee on Horticultural Education will study the horticultural courses at the different universities, agricultural colleges, and other institutions in Canada, the United States, and abroad, and will make recommendations, from time to time, in the form of a report, towards the improvement of horticultural courses in Canada, and the future training of horticulturists and gardeners. After being presented at the Annual Convention, it will be disseminated among the horticultural members.

5. *Implements and Machinery*—Chairman, W. J. Tawse, 750 Wilson Avenue, Notre Dame de Grace, Montreal, Quebec; the Committee on Implements and Machinery will learn as much as possible about any new horticultural implements and machinery that either are known to have proven better than older ones or promise to be better, and will, from time to time, make a report at the Annual Convention on the newer and promising ones in order that the information may be disseminated to all the members of the C.S.T.A. who are especially interested in Horticulture.

6. *Marketing* — Chairman, P. A. Fisher, Burlington, Ontario; the Committee on Marketing will make a special study of markets and marketing conditions with a view to furnishing fruit growers and horticulturists generally with information that is likely to prove useful to them. This Committee will report, from time to time, at the Annual Convention, and the information given will afterwards be disseminated among the horticultural members.

7. *Research*—Chairman, G. H. Harris, University of British Columbia, Vancouver, B.C.; the Committee on Research will endeavor to obtain the latest information in regard to research projects of interest to horticulturists in Canada and elsewhere so as to bring to the attention of members the names of the institutions where investigations are being carried on, the personnel of such institutions and such results as are thought to be of the greatest value to the members interested in horticulture. This to be presented to the Horticulture Group, from time to time, and then disseminated among the horticultural members.

8. *Technique*—Chairman, T. G. Bunting, Macdonald College, P.Q.; the Committee on Technique will endeavor to learn, or obtain, the latest and best technique on the culture of different kinds of horticultural plants; on methods of planning projects; on methods of recording the results of experiments and investigations, both in the field and in the inside laboratory; on technical descriptions of fruits, vegetables and ornamental plants; on standards for judging fruits, vegetables and ornamental plants. A report on the findings of the Committee is to be presented, from time to time, at the Annual Convention and then disseminated among the horticultural members.

9. *Varieties of Fruits*—Chairman, E. F. Palmer, Horticultural Experiment Station, Vineland, Ontario; the Committee on Varieties of Fruits will present a report, from time to time, at the Annual Convention, on new fruits of merit and give lists of fruits recommended for different

parts of Canada. The report to be afterwards disseminated among horticultural members.

10. *Varieties of Ornamental Plants*—Chairman, F. E. Buck, University of British Columbia, Vancouver, B.C.; the Committee on Varieties of Ornamental Plants will present a report, from time to time, at the Annual Convention, on new ornamental plants of merit and give lists of species and varieties of ornamental plants recommended for different parts of Canada. The report to be afterwards disseminated among horticultural members.

11. *Varieties of Vegetables*—Chairman, T. F. Ritchie, Central Experimental Farm, Ottawa, Ontario; the Committee on Varieties of Vegetables will present a report, from time to time, at the Annual Convention, on new varieties of merit and give lists of vegetables recommended for different parts of Canada. The report to be afterwards disseminated among horticultural members.

W. T. Macoun,
Organizer of Committees.

Notes and News

J. N. Ponton (Laval '12), former Vice-President of the C.S.T.A., and Director of *Le Bulletin des Agriculteurs* since 1920, died at Montreal on December 11th, 1929.

W. T. Macoun, Dominion Horticulturist, has been elected a Vice-President of the American Pomological Society, and awarded the Wilder Silver Medal given by the Society annually in recognition of his accomplishments in fruit breeding and horticulture generally.

R. Harcourt (Toronto '93), Professor of Chemistry at the Ontario Agricultural College, and A. T. Charron (Ottawa '92), Assistant Deputy Minister of Agriculture for Canada, have been honoured by the French Government with the award of the Cross of Agricultural Merit. The award is the result of the visit to Canada in August, 1929, of a group of students and faculty from the National School of Agriculture at Grignon, France, and of the assistance given towards the success of that visit.

J. G. Ferguson (Toronto '28) is attending the College of Education at Toronto this year.

Jacob Biely (British Columbia '26) has obtained the degree of M.S. in bacteriology from the Kansas State Agricultural College and is again attached to the staff of the University of British Columbia.

S. C. Acheson (Manitoba '28) has been appointed teacher in mechanics and mathematics at the School of Agriculture, Raymond, Alta.

R. E. English (Alberta '28) has joined the staff of the Dominion Seed Branch and his mailing address is c/o Provincial Seed Cleaning Plant, Edmonton, Alta.

Applications for Membership

The following applications for regular membership have been received since December 2, 1929:—

Black, L. M. (British Columbia, 1929, B.S.A.) Vancouver, B.C.
Carr, W. L. (McGill, 1906, B.A.) Huntingdon, P.Q.
Edmunds, F. H. (Liverpool, 1923, M.Sc.) Saskatoon, Sask.
Elcheshen, D. M. (Manitoba, 1928, B.S.A.) Winnipeg, Man.
Fitzpatrick, R. E. (McGill, 1929, B.S.A.) Toronto, Ont.
Gaddes, W. H. (Toronto (Ont. Vet. College), 1892, D.V.S.) Vancouver, B.C.
Hagborg, W. A. F. (Manitoba, 1929, B.S.A.) Toronto, Ont.
Howatt, J. L. (McGill, 1929, B.S.A.) Macdonald College, P.Q.
Jaap, R. G. (Saskatchewan, 1929, B.S.A.) Madison, Wis. U.S.A.
Mitchell, J. (Saskatchewan, 1924, B.S.A., Wisconsin, 1929, M.S.) Saskatoon, Sask.
McCormack, R. B. (McGill, 1929, B.S.A.) Fredericton, N.B.
Odlum, R.M. (British Columbia, 1929, B.S.A.) Victoria, B.C.
Ramsay, R. (Saskatchewan, 1929, B.S.A.) Saskatoon, Sask.
Ramsbottom, J. M. (Toronto, 1929, B.S.A.) New Liskeard, Ont.
Sylvestre, P. E. (Montreal, 1923, B.A., 1927, B.S.A., Wisconsin, 1928, M.Sc.) Ottawa, Ont.
Wasson, F. C. (Toronto, 1922, B.S.A.) Victoria, B.C.
Williamson, H. F. (McGill, 1915, B.S.A.) Toronto, Ont.
Wright, E. G. (Toronto, 1928, B.S.A.) Guelph, Ont.

American Society of Agronomy Announces Winners of Nitrogen Research Awards

At its annual meeting in Chicago on November 14th, 1929, the American Society of Agronomy named three agricultural scientists to receive the Chilean Nitrate of Soda Nitrogen Research awards for their outstanding accomplishments in nitrogen research in agriculture. They are:

Dr. P. L. Gainey, Professor of Soil Bacteriology, Kansas State Agricultural College, Manhattan, for his study of the free nitrogen-fixing bacteria in their relation to the nitrogen content of the soils of the Great Plains.

Professor C. A. Mooers, Director, Tennessee Experiment Station, Knoxville, for his study of the economic use of nitrogenous fertilizers.

Dr. S. A. Waksman, Associate Professor of Soil Microbiology, New Jersey State College of Agriculture, New Brunswick, N.J., for his research concerning soil organic matter.

The purpose of the Chilean Nitrate Research award is to promote nitrogen research in agriculture.

It will be remembered that Dr. F. T. Shutt, Dominion Chemist, was one of the recipients of this award in 1928, the year of its establishment.

Canadian Phytopathological Society

The final meeting of the Canadian branch of the American Phytopathological Society was held at Ottawa on December 19th and 20th, 1929. At this meeting it was decided to form a Canadian organization quite apart from the American one of the same name and, consequently, the meeting became the organization meeting of the Canadian Phytopathological Society. The meeting was well attended by plant pathologists from all parts of Canada and the following officers were elected for 1930:—President, H. T. Güssow, Dominion Botanist, Central Experimental Farm, Ottawa, Vice-President, W. P. Fraser, Professor of Plant Pathology, University of Saskatchewan, Saskatoon, Sask., Secretary-Treasurer, T. G. Major, Tobacco Specialist, Central Experimental Farm, Ottawa, Councillors, D. L. Bailey, Associate Professor of Plant Pathology, University of Toronto, Toronto, Ont., and J. G. Coulson, Professor of Botany, Macdonald College, P.Q.

Western Canadian Society of Agronomy

At the annual meetng of the Western Canadian Society of Agronomy held at the University of Alberta, Edmonton, Alta., during the last week of December, the following officers were elected for 1930:—President, J. B. Harrington, Professor of Field Husbandry, University of Saskatchewan, Saskatoon, Sask., Vice-President, J. R. Fryer, Associate Professor of Genetics and Plant Breeding, University of Alberta, Edmonton, Alta., Secretary-Treaurer, A. T. Elders, Assistant Professor of Agronomy, Manitoba Agricultural College, Winnipeg, Man., Members of the Executive, K. W. Neatby, Cereal Specialist, Dominion Rust Research Laboratory, Winnipeg, Man., and J. G. Taggart, Superintendenot, Dominion Experimental Farm, Swift Current, Sask., Curator, J. D. Newton, Associate Professor of Soils, University of Alberta, Edmonton, Alta.

The next annual meeting in December, 1930, will be held at the Manitoba Agricultural College, Winnipeg, Man.

President and General Secretary Recovering

Professor J. P. Sackville, President of the C.S.T.A., and Mr. Fred. H. Grindley, General Secretary, who were seriously ill during the month of December, are both considered now out of danger.